THE
BRITISH JOURNAL OF SURGERY

VOL. XIV. JANUARY, 1927. No. 55.

EPONYMS.

BY SIR D'ARCY POWER, K.B.E., LONDON.

XXIII. SPENCER WELLS' FORCEPS.

WHEN I was house surgeon to Sir William Savory at St. Bartholomew's Hospital in the year 1883, a single pair of spring forceps was alone provided to arrest the bleeding even in so large an operation as amputation through the middle or upper third of the thigh. At that time and for some years afterwards it was the duty of the assistant surgeon always to be present to help his chief at every operation. Amputations, the removal of tumours, ligature of arteries in their continuity, and the relief of strangulated herniæ were the usual operations, and by long association the assistant surgeon had learnt every movement of his chief, who always operated for speed. The control of the bleeding was not as difficult as might be thought. The main artery was controlled by digital pressure in cases of amputation, and, as the surgeons had all graduated through the dissecting room, each vessel was picked up in turn, ligatured with silk, and when all the normally situated vessels had been thus tied the pressure on the main vessel was relaxed and any smaller bleeding points were tied.

The need for improved mechanical means to stop bleeding was felt in places where such skilled assistance as in the older institutions was not attainable and where abdominal surgery was beginning to be practised.

Attempts were made, certainly as early as 1860, to replace the spring orceps by others with scissors handles and a catch on the shanks, but a single pair was still considered sufficient for each operation, and multiple forceps did not come into use until the little bulldog forceps which, as physiologists, we used to call Krönecker's forceps spread from the physiological laboratory to the operating theatre.*

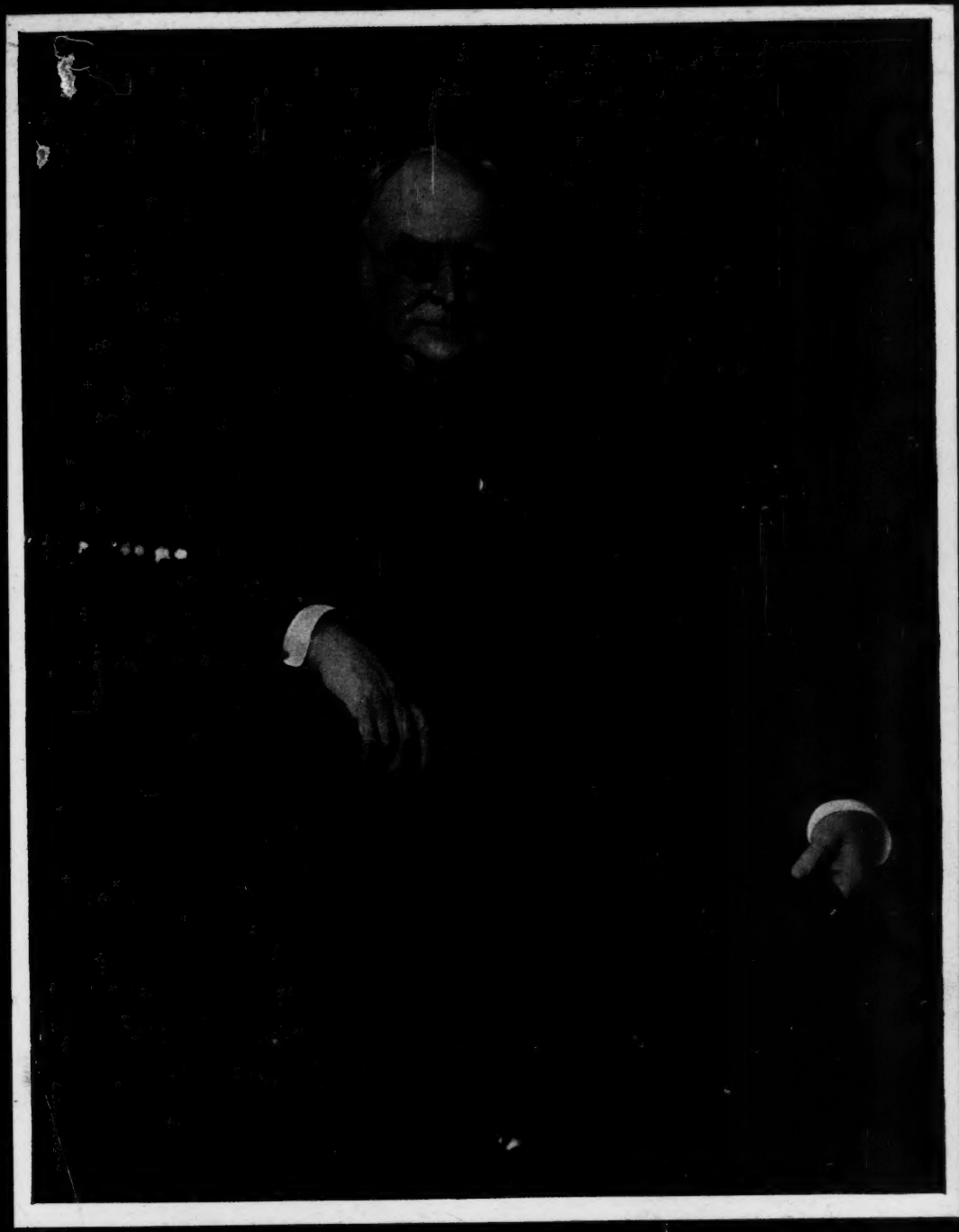
*Mr. Alban Doran, in the typed copy of a "Descriptive Catalogue of Gynæcological Instruments in the Museum of the Royal College of Surgeons of England", gives the following "Notes on the Development of the Pressure forceps. In 1853 Webber invented his anti-ligature forceps. Spencer Wells used bulldog forceps in all his earlier ovariotomies. In 1858 Charrière introduced his dressing forceps with handles, bows or rings as in scissors and a catch on the shanks just above the handles. In 1862 Koeberlé applied a Charrière's forceps to a bleeding ovarian artery: it came away spontaneously on the sixth day. In

Mr. Spencer Wells published his "Remarks on Forcipressure and the use of Pressure-Forceps in Surgery" in the *British Medical Journal*, 1879, vol. i, p. 926. He there says: "Mr. Spencer Wells (Samaritan Hospital) has introduced a kind of artery and torsion forceps, which very conveniently replace the old spring artery-forceps of Liston and the bulldogs used for *the temporary stoppage of bleeding vessels during operations*, whilst they are the most readily applied of any of the varieties of torsion forceps met with in the shops. They were first made for Mr. Wells by Krohne and Sesemann. The grasping and holding extremity is roughened by rather deeply cut transverse teeth, so that *the bleeding vessel is forcibly compressed and its coats squeezed or almost crushed together*. This is often sufficient to stop the bleeding without any torsion, especially if the instrument be left on the vessel for a minute or more. But if the vessel be large then two or more rotations may be added. Instead of the spring-catch, the fastening is effected by a Mathieu's catch in the handles. This is quite as easily fixed and opened as the spring and is much less likely to get out of order. The instrument is made of steel, but is coated with nickel, which prevents any rusting after use." This passage, quoted from an article which appeared in the *British Medical Journal* of Jan. 10, 1874 [vol. i, page 47], proves, says Mr. Spencer Wells, "that before 1874 I had employed forcipressure, not only for the *temporary* arrest of bleeding during surgical operations, but had designed forceps for the express purpose of so squeezing or crushing the coats of the bleeding vessel together, as *permanently* to stop bleeding from vessels of moderate size. I do not wish to enter into a discussion between MM. Koeberlé and Péan, nor to prove that I had preceded both of them by many years in the use of forcipressure. My chief object is to bring more prominently before the profession the many and great uses of this simple and rapid mode of stopping bleeding and describing what I believe to be the best form of pressure-forceps hitherto constructed."

"I can hardly recollect when I first began to use forceps instead of the fingers of an assistant for temporarily stopping bleeding during operations; but I believe I learned it from Mr. Bowman before he left King's College. I had often admired in the private and hospital practice of Sir William Fergusson the ready way in which Mr. Henry Smith and the late Mr. Price would instantly stop a spouting vessel by the finger and tie it at a glance from the great operator. But I well remember seeing Mr. Bowman extirpate a very large tumour from the neck, and quietly put a 'bull-dog' upon every considerable vessel as he divided it. This must have been in 1854; because when I went to the Crimea in 1855, I took a number of 'bull-dogs' with me; and after my return in 1856 I never went to any serious operation without several of different sizes. I used them in all my earlier cases of ovariotomy

---

1865, Verneuil secured the bleeding stump of a uterine polypus by leaving a polypus forceps attached to it for two days. In December 1865 Elser constructed Koeberlé's pince hémostatique: after October 1867 that surgeon removed the forceps at the end of the operation instead of leaving it on the vessel for a day or longer. In 1868 Gueride constructed for Péan an instrument for forcipressure—a modification, like Koeberlé's, of Charrière's, with Charrière's lock. In 1872, Spencer Wells first employed this pressure forceps after testing several designs, and in 1878 he adopted the later form with superimposed blades."



(beginning in 1858) for stopping any vessel which bled in the abdominal wall divided in the first incision. I cannot remember precisely when I began to find that the 'bull-dogs', used at first only as a means of temporary compression, were sufficient to close permanently vessels of moderate size; but in 1863 I began to increase the size of the 'bull-dogs' and to attach long pieces of silver or iron wire to them, so that when used on omental vessels, or on bleeding vessels from torn adhesions on the inner surface of the abdominal wall, they should not be forgotten or lost. Then, as torsion came into more general use, and various forms of torsion forceps were contrived, I arrived at the form of instruments described above. Mr. Krohne tells me that he made the first of these forceps for me early in 1872. Koeberlé and Péan's instruments have the great disadvantage of an open space between the blades, which admits of entanglement of one instrument with another, or of the passage of omentum or other structures. This was a fault in my own earlier instruments. It has been completely corrected in the later instruments made for me by Mr. Hawksley without at all lessening the compressing power exerted on the vessel. In October 1878 Mr. Hawkesley carefully tested the compressing power of different forceps when opened by a piece of leather one *millimètre* thick between the jaws of the forceps, and covering about four teeth from the points. The following table gives the result, as well as the force required to be exerted by the hand in closing the handles or fastening the catch or catches under each condition.

POUNDS AVOIRDUPOIS EXERTED BY FOUR TEETH OF THE END OF THE FORCEPS WHEN ONE MILLIMETRE APART.

FORCEPS	FIRST CATCH	SECOND CATCH
Koeberlé	—	3¼
Péan	8	12
S. Wells (old)	22½	—
Ditto (new)	12	22½

It may be seen that in my old instrument there is only one catch. And in my new one, the second catch only exerts the same power as the first catch of the old instrument. But this is six or seven times greater than the second catch in Koeberlé's—and nearly double that of Péan's. When only the first catch in Koeberlé's instrument is closed, the points are separated about half a *centimètre*, so that they only compress anything more than that thickness. I have used all these instruments, but find them much less handy than my own, in which the handles meet without leaving any opening between them. The rings do not admit the thumb and finger too far; and the end which compresses the vessel is so bevelled, that, if it be desirable to apply a ligature, the silk will easily slip over the forceps and not tie them together. Thus my instrument is not only useful in forcipressure and in torsion, but enables the surgeon to dispense with any other kind of artery-forceps if he wish to apply a ligature."

The history of the pressure forceps is to be found in an interesting

article by Mr. Alban Doran (*British Medical Journal*, 1915, vol. i, p. 555). It is headed: "The Development of the Pressure Forceps (Webber's—Koeberlé's—Péan's—Wells's). In Chronological Order from the Original Reports."

Thomas Spencer Wells was born at St. Albans in 1818, the eldest son of William Wells, a builder. He early showed an interest in natural science, and was apprenticed to Michael Thomas Sadler, a highly-respected general practitioner at Barnsley in Yorkshire. He lived for a year with the parish doctor at Leeds, and there attended the lectures of the second Hey and the elder Teale, whilst he followed the practice of the Leeds Infirmary. In 1836 he entered Trinity College, Dublin, and received instruction from William Stokes, Sir Philip Crampton, and Arthur Jacob. Three years later he came to St. Thomas's Hospital in London, where his education was completed under J. H. Green, Benjamin Travers, and Frederick Tyrell. At the end of his first year he was awarded a prize for the most complete and detailed account of the post-mortem examinations made during the time of his attendance at the hospital. He was admitted a Member of the Royal College of Surgeons of England in 1841, and joined the Navy as Assistant Surgeon. He served in Malta for six years, combining civil practice with his naval duties, and acquired so good a reputation as a surgeon that the honour of a Fellowship of the Royal College of Surgeons was conferred upon him in 1844. He left the Navy in 1848, and paid a visit to Paris to see the gunshot wounds coming from the barricades in the June of that year. He afterwards visited Egypt with the Marquis of Northampton and made some observations on malaria. In 1853 he began to practise in London as an ophthalmic surgeon, and in the following year he was elected surgeon to the Samaritan Free Hospital for Women and Children, which was then little more than a dispensary, and he was appointed editor of the *Medical Times and Gazette*. He resigned his posts on the outbreak of the war in the Crimea and proceeded to Smyrna, where he became surgeon to the Civil Hospital. He returned to London in 1856 and took up his former post of Surgeon to the Samaritan Hospital.

In 1848 Wells believed ovariotomy was an unjustifiable operation as surgery then stood; in April, 1854, he assisted Baker Brown at his eighth operation for the removal of an ovarian tumour. The patient died, and it was not until 1858 that Wells himself operated for a similar condition. The remainder of his life was practically a history of the operation from its earliest and imperfect stage until it became one of the routine operations of surgery. Ovariotomy was accepted by the medical profession as a legitimate operation about 1864, and its acceptance was largely due to the wise manner in which Wells conducted his earlier operations. He invited men of authority to see him operate; he published series after series of cases giving full descriptions of the successful as well as of the unsuccessful results, and he constantly modified his methods, always in the direction of greater simplicity. His operations were models of surgical procedure. He worked in absolute silence; he took the greatest care in selecting the instruments, and he submitted his assistants to a rigid discipline.

Wells may thus be looked upon as the founder of modern abdominal

surgery. He found ovariotomy a discredited operation, but even before the introduction of antiseptic methods his success was sufficient to render its performance justifiable. Coupled with the improved surgical procedure introduced by Lister, the principles governing the operation of ovariotomy have been applied to the uterus, the kidneys, the liver, the spleen, and the intestines, all of which are now subjected to surgical interference and often with the happiest results. Yet Wells had at first no easy battle to wage. The whole weight of surgical opinion was against him. His perseverance, his transparent honesty, his absolute sincerity, and his fighting powers at last overcame all opposition, and he lived to see his operation approved, adopted, and fruitful beyond all expectation.

Wells had many interests outside his profession. He was an ardent advocate for cremation; he was a good judge of horses, rode well, and, in later life, was to be seen daily driving himself in a phaeton with a well-matched pair of horses from his house in Golders Green to his rooms in London.

He was President of the Royal College of Surgeons of England in 1883, and in the same year he was created a baronet. He died near Cannes in 1897, and his body was cremated at Woking. He left five daughters and one son by his wife, Elizabeth Lucas, daughter of James Wright, solicitor, of Sydenham, who practised in New Inn.

* * * * * *

The portrait is from an oil painting by Rudolf Lehmann hanging in the hall of the Royal College of Surgeons of England. It represents Spencer Wells in his robes as President of the Royal College of Surgeons.

ACUTE PANCREATITIS.

By DIGBY CHAMBERLAIN, Leeds.

Acute pancreatitis is the most acute, agonizing, and one of the most fatal conditions which we are called upon to treat inside the abdomen. The severity of the pain and its sudden onset cause the sufferer to seek immediate advice. In a number of cases the label 'acute abdomen' is loosely applied, not because the disease presents any difficulty in diagnosis, but because it is not kept in mind by the observer. Deaver says, "Unless a surgeon has seen previously two or three cases of acute pancreatitis, or unless he keeps the condition constantly in mind, it is seldom that a correct diagnosis is made before opening the abdomen".

Diagnosis.—I do not wish to go over the symptoms of the disease, as they are fully and accurately recorded elsewhere, but desire to emphasize their severity and the acuteness of their onset. There are two signs to which I must refer later on. The first is the marked cyanosis which was first recorded by Halstead, and the second is the discoloration in the flank due to a direct retroperitoneal digestion by the pancreatic ferments to which Grey Turner has drawn attention. If it is thought necessary to confirm the diagnosis of acute pancreatitis, Lowe's test and the diastatic value of the urine are both confirmatory. Other and more elaborate tests are not usually available in an emergency, and moreover are quite uncalled for.

Statistics.—Acute pancreatitis is an uncommon disease, only 21 cases having been treated at the General Infirmary at Leeds in the decade 1915–24. This is equivalent to one in every 5000 surgical admissions. The average age of these patients was 50, and females were attacked more frequently than males, the figures being 62 per cent and 38 per cent. Of the whole series of 21 cases, 8 died, which is equivalent to a mortality of 38 per cent. Three cases were not operated on, and two of them died. That the third case was suffering from acute pancreatitis seems almost certain, as the diastatic value of his urine was found to be 200 units. It has been stated that cases do recover without operation. We must admit this possibility, as patients are sometimes seen at operation after a supposed acute cholecystitis, when the pancreas is swollen, and large areas of fat necrosis are present. These cases have obviously recovered spontaneously from their acute attack, but we see that there is a mortality of 66 per cent for patients treated medically.

In 13 cases the treatment was drainage of the lesser sac. In these the lesser sac was opened, usually between the stomach and transverse colon, and the peritoneum covering the pancreas was incised. The pancreas was explored with the finger, and free sloughs, if present, were removed. This exploration should be very gentle, and should never be attempted with a sharp instrument, as the splenic or other vessels may be opened and give rise

to very troublesome hæmorrhage. A rubber drainage tube, carefully packed off from the rest of the abdomen by gauze swabs, was then put down to the anterior surface of the gland. Five of these cases died, which equals a mortality of 38·5 per cent. In the remaining 5 cases operated on, in addition to drainage of the lesser sac, a tube was put into the gall-bladder. One of these patients died, so that by this method the mortality is brought down to 20 per cent. Although it may be fallacious to draw conclusions from such a small series of cases, it would appear that drainage of the gall-bladder and lesser sac has only half the mortality of drainage of the lesser sac alone.

It is interesting to note that 9 cases of the series gave a history of recurrent attacks of abdominal pain, situated in the upper abdomen and continuing over a number of years. For two or three weeks these attacks had been more severe, and had culminated in the real acute attack. One case, which recovered, had had typhoid fever.

Post-mortem examination in 6 of the 8 cases which died showed: single cholesterol stone in 2 cases, multiple small stones in 1, no stones in 2, congested gall-bladder in 1. No case showed obstruction at the ampulla of Vater. In the two other cases there was no post-mortem.

Drainage.—When the question of drainage is being considered, posterior drainage of the lesser sac must be discussed. The lumbar discoloration, which has been already mentioned, is due to a digestion of the retropancreatic tissues, which, aided by gravity, extends towards the skin of the back. In one case, after operation, a fluctuating swelling appeared below the last rib on the left side, due apparently to an extension of this process. Drainage in this position would appear to be rational, and, in addition, would be assisted by gravity; but unfortunately the posterior relations of the pancreas are so numerous and important that a stab through them cannot be recommended as a routine procedure.

I have worked out anatomically what I think is the only possible method of posterior drainage. It consists in resecting a portion of the tenth left rib in the mid-axillary line, and aims at draining the lesser sac in the region of the tail of the pancreas. I have not yet had an opportunity of employing it on a patient. When I have been able to do so, I hope to publish the method in detail.

Sequelæ.—I have been able to follow up only 6 of the 13 cases which recovered. Two of them are dead, one eight years and the other two years after operation. Both these cases were elderly men, one being 72, and from the facts at my disposal it appears that they died from some other cause. The remaining 4 are tolerably well. Three complain of a certain amount of indigestion, but say that, with careful attention to their diet, they are quite comfortable. This indigestion is to be explained by the deficiency in pancreatic juice, and the administration of liquor pancreaticus is of considerable advantage to them. The fourth case was a woman who has had three children since she was operated on.

Although they do not appear in these cases, there are more definite sequelæ in other cases which have been brought to my notice. In one patient a cystic swelling made its appearance in the upper abdomen after the wound had been allowed to close. A second operation was undertaken, when a false

pancreatic cyst was found and drained. Complete recovery followed. A second case has developed a pancreatic fistula, which is still discharging eleven months after the original operation. If the drainage tube had been taken out early in this case and the wound had been allowed to close, a cyst would almost certainly have developed. On the other hand, if the tube is left in too long, the walls of the track become sclerosed, epithelialization takes place from the surface, and a permanent sinus may be the result. It appears, therefore, that the tube should be removed as early as possible, but never until the discharge has become small in amount.

A dangerous time in the convalescence of these cases is from the tenth to the fourteenth days, when the sloughs are beginning to separate. There is a risk of secondary hæmorrhage, and there is a recrudescence of pain and a rise of temperature, due to interference with the drainage. When this period has been successfully negotiated the chances of the patient's eventual recovery are practically certain.

PATHOLOGY.

Pathologically it is found that the pancreas is the seat of an inflammatory swelling, which becomes tense and presses on the cœliac plexus, and so the acute nature of the pain and the severe accompanying shock are explained. This is followed by an effusion into the lesser sac of the peritoneum, which later suppurates and accounts for the fullness or swelling in the upper abdomen. This exudate then finds its way through the foramen of Winslow, and a general involvement of the peritoneum results. Scattered throughout the abdomen and elsewhere, areas are seen where the pancreatic lipase which has been liberated has saponified the neutral fats.

There appear to be five possible causes of these findings: (1) An auto-digestion of the pancreas; (2) An infection of the pancreas; (3) Hæmorrhage and digestion of the clot; (4) Pancreatic calculi; (5) A combination of (1) and (2). That the pancreatic ferments take some action in the process is shown by the presence of fat necrosis and by the lumbar discoloration, to which attention has been directed. Trypsinogen can be activated by entero-kinase or by infection, but not by the action of normal bile. At one time acute pancreatitis was thought to be due to a regurgitation of intestinal contents through the ampulla of Vater, organisms being in this way brought to the pancreas, but this theory has now been abandoned. If this regurgitation does not take place, trypsinogen cannot be activated by the succus entericus and must be activated by infection. Hæmorrhage can be definitely excluded when it is remembered that trauma and scurvy may both be the cause of bleeding into the pancreas, but that in neither of these conditions does an acute pancreatitis supervene. A calculus might cause an area of lowered vitality which would be vulnerable to organisms present in the circulation; by blocking a duct it might increase the virulence of organisms already present, as occurs in obstruction of the lumen of the appendix: but as it has been shown that the pancreatic ducts are normally sterile, and as the association of acute pancreatitis with calculi has not been observed, this theory of causation must be abandoned.

The cyanosis which is such a marked feature of these cases probably depends on the presence of a septicæmia; this is a further point in favour of an infectious origin. Once trypsinogen has been converted into trypsin by an infective agent, autodigestion occurs, lipase is liberated, is activated merely by contact with normal tissues, and produces areas of fat necrosis.

The source of the infection might be: (1) Regurgitation of infected bile into the pancreas; (2) Lymphatic infection of the pancreas from the gall-bladder; (3) Infection from an inflamed common bile-duct; and (4) Infection from elsewhere.

I have had the opportunity of examining the bile in four cases of the disease at the time of operation, and in all of them a hæmolytic streptococcus was present. On superficial examination the gall-bladder appeared to be perfectly healthy in three of these cases; in the other case obvious disease was present. The gall-bladder would therefore appear to be the site of the infection.

		Author Per cent	Mann Per cent
a. Separate	..	28	31
b. $\frac{1}{8}$ inch	..	23	45
$\frac{1}{4}$,,	..	19	
$\frac{3}{8}$,,	..	4	20
$\frac{1}{2}$,,	..	21	
$\frac{3}{4}$,,	..	3	
c. Duct of Santorini		2	4
		100	100

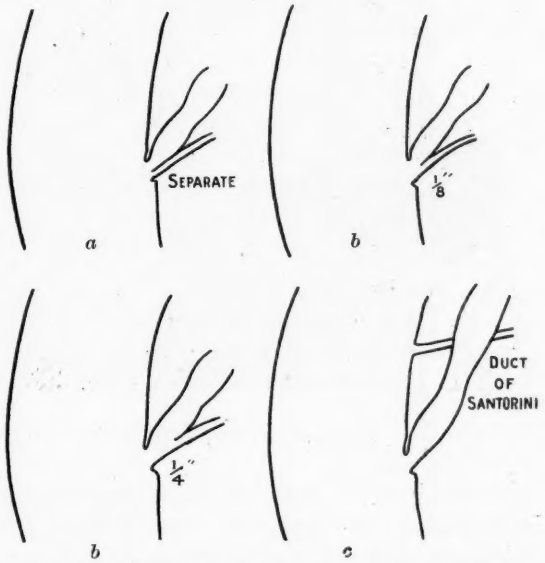


FIG. 223.—Anatomical variations in the openings of the common bile-duct and pancreatic duct.

With regard to (3), Maugeret has shown that in none of these cases is an inflammation of the mucosa of the common duct present. It is therefore impossible for infection to extend directly into the gland from this source, an attractive suggestion when it is remembered that in a large percentage of cases the common duct is embedded in the head of the pancreas.

The next question is as to whether the infection reaches the pancreas by way of the bile or by the lymphatics. That the latter is likely has been shown by Deaver and by Maugeret, who have emphasized the very close anatomical connections between the lymphatics of the gall-bladder and pancreas. Lymph from the gall-bladder normally drains into the glands at the hilum of the liver, but once these glands are blocked, a retrograde flow takes place into the pancreatic lymph channels. In spite of this it is widely held that the regurgitation of bile along the duct of Wirsung is the causative factor. In order to determine the possible anatomical variations and the possibilities of the regurgitation theory, I have examined the junction of the common bile-duct with the pancreatic duct in 100 consecutive post-mortem cases. This has previously been done by Mann,

whose figures I give also. The types appear to be: (*a*) Where the two ducts open separately into the duodenum at the apex of a papilla; (*b*) Where they join together to form a common channel of varying length which opens on the papilla; and (*c*) Where the duct of Wirsung is small and drains into the duct of Santorini, which becomes the chief duct of the gland. (***Fig.* 223.**)

The opening of this common channel takes place on the summit of a papilla in two cases out of three; in the remaining case the opening is either flush with the duodenal mucosa, or is in a depression covered over by one of the valvulæ conniventes.

In one normal case there was bile staining of the pancreatic duct, showing (1) that bile may regurgitate, but (2) if it is healthy it does not cause an acute pancreatitis. Blockage of the ampulla and regurgitation of bile along the

FIG. 224.—Sarcoma involving ampulla of Vater.

pancreatic duct would seem to be possible in 47 per cent of cases, but Judd has shown that the sphincter of Oddi embraces the terminations of the two ducts in 95·5 per cent of bodies. If this muscle is thrown into spasm, it compresses the openings of both ducts, and it is only in the remaining 4·5 per cent that regurgitation is possible. That it can only occur in this small percentage of cases might account for the rarity of the condition.

One fact strongly against this theory has been very obvious. At the point of junction of the ducts, as they are getting closer together, one side of one duct and one side of the other fuse, and this common wall becomes thinner until it is represented by two layers of epithelium with some connective tissue separating them. This thin wall is prolonged down for some distance, so that if the common bile-duct is laid open, it appears as if the opening into

the pancreatic duct were guarded by a valve, and I have very little doubt that this fold acts normally as a valve. As the common bile-duct is many times bigger in section than the pancreatic duct, this valve could not prevent a flow from the pancreatic into the common bile-duct, but is only competent when called upon to prevent a flow in the reverse direction. If an obstruction takes place at the ampulla, bile and pancreatic juice will be held back, and as the pressure rises this valve will close. The only thing that can open the valve is the secretory pressure of the pancreatic juice, and if this causes a flow, it will, of course, be into, and never from, the common bile-duct, which would be necessary if the regurgitation theory were the correct one.

Among my 100 cases were 4 of acute pancreatitis. In one (*Fig.* 224) there was a sarcoma of the duodenal wall involving the ampulla of Vater, but on account of the extent of the growth it was not possible to make out the exact relations of the ducts to one another. The second case showed a small polypus at the ampulla, narrowing but not occluding its lumen, and the ducts were arranged as in *Fig.* 225. The pancreatic and common bile-ducts joined together to form a common channel $\frac{1}{4}$ in. long which opened on the summit of a papilla. The third case showed no pathological condition in the ducts, which had the same anatomical relations as the second case, except that this common channel was $\frac{3}{8}$ in. long. The fourth case had exactly the same anatomical structure as the third case, but the gall-bladder was acutely inflamed and full of stones, three of which had found their way into the common duct, but were not impacted at the ampulla.

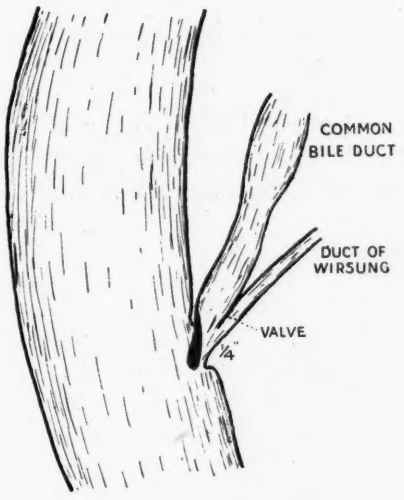


Fig. 225.—Ampulla of Vater with polypus. The nature of the valve guarding the duct is seen.

Post-mortem notes of two cases read as follows: (1) Slough present, consisting of anterior part of middle of pancreas; head and tail appear normal. Pancreatic duct normal. (2) Pancreas normal except for a superficial abscess of the head. From this it appears that the lesion does not start in the head of the pancreas in the neighbourhood of the duct of Wirsung, but on the anterior surface of the gland. If infection spreads by the ducts, it is quite reasonable to suppose that the part attacked might be in connection with the smaller ducts on the surface of the gland, but not necessarily anteriorly. The lymphatics from the gall-bladder are in close connection with those lying on the surface of the pancreas, and these two cases appear to support the probability of an infection by this route. An infection of the smaller ducts would be just as likely to attack the tail or posterior surface of the gland.

The two cases where a definite lesion was found at the ampulla might seem to indicate a blockage there, with regurgitation of bile along the pancreatic duct. The polypus did not completely block the ampulla, but tended rather

to hold it open, and the sarcoma, by making its walls rigid, probably also kept it patent. These lesions, by keeping the ampulla open, probably allowed an infection to enter the ducts and to ascend to the gall-bladder, from which the pancreas became infected.

CONCLUSIONS.

1. In acute pancreatitis there is an infection of the gall-bladder, caused by a hæmolytic streptococcus.
2. Infection travels to the pancreas by way of the lymphatics.
3. Regurgitation of bile along the pancreatic duct is prevented by a valve which guards its opening.
4. The treatment is operative.
5. Operation should consist in drainage of the lesser sac and gall-bladder.
6. As the infection is streptococcal, serum therapy might be tried with advantage.

I am indebted to the Honorary Staff of the General Infirmary at Leeds for the help they have given me in the preparation of this paper, and for the clinical and pathological material which they have placed at my disposal.

ON LEPTOMENINGIOMAS (ENDOTHELIOMAS) OF THE SPINAL CORD.*

By J. R. LEARMONTH, Glasgow.

SUMMARY OF CONTENTS.

I. Foreword
II. Historical Introduction
III. Development of the Arachnoid
IV. Structure and Relations of Adult Leptomeninx
V. Incidence of Leptomeningiomas
VI. Occurrence with other Tumours
VII. Pathological Anatomy
VIII. Etiology
IX. Gross Pathology
X. Microscopic Appearances
XI. Clinical Physiology of Spinal Cord
XII. Pathology of Compression of Spinal Cord
XIII. General Clinical Features of Leptomeningiomas
XIV. Leptomeningiomas in Special Situations
XV. Disturbances of Vesical, Rectal, and Sexual Functions
XVI. Accessory Aids to Diagnosis
XVII. Determination of Level of Tumour
XVIII. Differential Diagnosis
XIX. Operative Treatment
XX. Prognosis
XXI. Case Histories.

I. FOREWORD.

In the following essay I have attempted to give a full account of those interesting tumours of the spinal cord hitherto named 'endotheliomas' or 'psammomas'. They have attracted the attention of many notable workers: among others, Sir John Bland-Sutton, Professor Harvey Cushing, and Dr. Mallory have advanced our knowledge of their pathological and clinical features.

In restricting my research to the features of a single type of tumour I have followed advice given to me by Dr. L. B. Wilson, Director of the Mayo Foundation. Professor Harvey Cushing (Cavendish Lecture, 1922, June 13) holds similar views; when indicating the lines along which advance may be

* A thesis founded upon work done during the tenure of a Medical Research Council Fellowship in Surgery in the Mayo Foundation (Mayo Clinic), Rochester, Minn., United States of America.

made in neurological surgery he says, ". . . what is perhaps better still, we may restrict our analysis to tumours of a single type in a given situation". In the preparation of my thesis I have had the privilege of access to all the records and facilities of the Mayo Clinic (through the Mayo Foundation), a privilege the value of which I cannot overestimate, extended to me with characteristic courtesy by Drs. A. W. Adson and H. E. Robertson. In addition I have included in my analysis cases reported in the literature from the year 1918 onward.

II. HISTORICAL INTRODUCTION.

The three great periods in the evolution of the science of pathology are reflected in the series of names which have been applied to the tumour which forms the subject of this essay. In the first period attention was directed to the local relations of growths, and to their ecology. After the advent of cellular pathology tumours were classified and reclassified in accordance with changing opinion as to the morphology of their cells. At the present time pathologists have come to regard embryology as an ancillary science, and attempt to classify neoplasms according to their ultimate origin.

Leptomeningiomas were first described within the skull, and so long ago as 1835 Cruveilhier depicted these growths, to which he applied the term *tumeurs cancéreuses des méninges*; although by the older writers they had been called *fungi durœ matris*. Some twenty years later Paget, at a loss for a satisfactory name, suggested that of *myeloid tumour*, while contemporary French opinion leaned toward the term *tumeur fibroplastique*. A little later Virchow, who had noted the occurrence of sand grains on the inner surface of the dura (a condition which he called 'meningitis arenosa'), proposed the term *psammoma* on the ground that he had observed similar sand bodies in the substance of such growths—a descriptive name still applied to certain specimens. Still later the same authority classified the tumour under the heading *sarcome der dura mater*. After a time this ceased to be sufficiently descriptive for the French school, which qualified the generic title in the term *sarcome angiolithique*.

About the same period His had proposed to classify the cells lining certain tissue spaces as *endothelium*. Golgi, believing that these tumours arose from so-called endothelial cells lining the perivascular spaces of the dura, introduced the word *endothelioma* into the terminology, and up to the present time it has been generally accepted and is employed in the prevailing nomenclature. From time to time various histologists have added descriptive adjectives to this name; thus Bizzozero and Bozzolo subdivided those growths appearing to spring from the dura mater into three groups: (1) *Sarcoma endothelioides alveolare*; (2) *Sarcoma endothelioides fasciculatum*; (3) *Fibroma endothelioides*. These names were intended to indicate the manner of arrangement of the tumour cells and their proportion relative to stroma.

It is a remarkable fact that, from a comparatively early period of cellular pathology, one is able to trace a minority of observers who appreciated the true origin of these growths. So far as I can ascertain, the first to draw attention to their close relationship to the arachnoid was Professor John

Cleland, of Glasgow University. In a paper which will still repay careful study he noted this relationship in two cases of brain tumour observed in his dissecting room. Histologically both growths were 'endothelioma'. A few years later Robin attributed similar growths to the soft membranes, and in accordance with the terminology of his time suggested the name *epithelioma.* In the light of recent research, which will be discussed hereafter, Robin would appear to have been nearer the truth than he knew.*

More than thirty years afterwards, though from a somewhat different approach, Schmidt arrived at the same conclusion regarding their origin. After an exhaustive histological study of the dura, he pointed out the unquestionable likeness of the islands of cells which are found among the strands of that membrane to the tufts of the arachnoid; and, further, that the cells forming these nests closely resembled the proper cells of an 'endothelioma'. Bland-Sutton has for many years upheld the arachnoid as the origin of the 'endotheliomas', a hypothesis which he reached upon similar grounds, though independently of Schmidt. In recent years Mallory from the histological side, and Cushing from the point of view of the surgical pathologist, have verified their origin from the arachnoid. Mallory in his paper, accepting the embryological origin of the arachnoid as from mesenchyme, proposed for them the term *arachnoid fibroblastoma.* The name cannot be discarded lightly, since—as will be shown later—the tumour cells have a definite fibroblastic potentiality. On the other hand, in view of the doubt which has been cast recently upon the mesodermal origin of the soft membranes, the less dogmatic term *meningioma* proposed by Cushing might be preferred. This observer based his view upon the fact that the so-called endotheliomas occur in those situations where arachnoid villi are found, or where buds of that membrane project into the dura, as well as upon histological grounds. As a compromise until the embryological controversy is settled, I would suggest the use of the term *leptomeningioma,* as denoting the source of the tumour without indicating its ultimate origin, and in my paper this name will be used. At the present time there can be no doubt that the leptomeningiomas arise from the soft membranes, and a more detailed consideration of the two theories concerning the development of these now becomes necessary.

III. DEVELOPMENT OF THE ARACHNOID.

Epiblastic Hypothesis.—Recently Harvey and Burr have doubted the origin of the leptomeninx from mesoderm. In the course of an inquiry into the manner of healing of the meninges, the former observer had noted that in the presence of an intact leptomeninx the dura healed without adhesion to the underlying membrane. This healing took place through a direct transformation of adjacent mesodermal cells into dura, and not from ingrowth of 'mesothelium' from the edges of the defect—a finding which seemed to indicate "some fundamental histogenetic difference between these two

* In the eighties, when Robin's paper was published, the cells lining serous spaces were classified as epithelium.

structures". Now Harrison has shown that the cells forming nerve-sheaths are derived from the neural crest; and nerve-sheath is to nerve-filament as leptomeninx is to central nervous system. The possibility of an epiblastic origin of the soft membranes was tested in a brilliant set of experiments involving the transplantation to a more caudal somite of portions of the cerebral vesicles of *Amblystoma punctatum*. The results of these experiments may be quoted:—

"The first series was that in which the mid-brain, optic vesicle, and the adjacent neural crest cells were transplanted into the region lying just anterior to the limb. The result of the procedure was that the transplanted neural tissue was completely invested by leptomeninx and dura. The second series involved the transplantation of a portion of the cerebral hemisphere into the same region, after the careful removal of neural crest cells. Examination of the result showed the growth of neural tissue with no leptomeninx, it being surrounded only by an incompletely formed dura".

This embryonic arachnoid is at first arranged as a syncytial mass, the meshes of which are comparatively small. The nuclei are oval and the greater part of the cytoplasm forms the connecting strands of the meshwork. As a result of the liberation of cerebrospinal fluid through the apertures at the caudal end of the fourth ventricle of the brain the tension within the meshes of the syncytium is increased, the more delicate protoplasmic processes rupture under the strain, become applied to the strands which have persisted, and are ultimately differentiated into the low cuboidal cells which line the trabeculæ between the adult arachnoid and the pia mater. The dura is formed by a process of condensation in the mesenchyme adjacent to the arachnoid.

Through the courtesy of Drs. Harvey and Burr I have had an opportunity of examining serial sections of the embryos used in these experiments. The appearances were very striking and in my opinion convincing. It is to be regretted that the technique is so delicate that a considerable time must elapse before their results can be confirmed by independent workers.

Mesoblastic Hypothesis.—According to this the syncytium around the neural tube is derived from mesenchyme, and its spaces are widened as described above. The actual membranous part of the arachnoid is first apparent as a zone of condensation in the perineural mesenchyme; this zone represents both the outer surface of the arachnoid and the inner surface of the dura mater. Later a line of cleavage appears; as may be observed in the adult, the separation is occasionally incomplete. Following the appearance of the line of cleavage the arachnoid rapidly attains its definitive structure; the 'mesothelium' covering its outer surface gradually loses its syncytial character and becomes a layer of cells of flattened cuboidal form resembling that of the cells on its inner or neural surface. Even at the fourth or fifth month of intra-uterine life these cells disclose their fibroblastic potentiality by surrounding themselves with fine fibroglia fibrils and more rarely fibres of collagen.

According to this hypothesis the leptomeninx is entirely a mesoblastic structure; its covering cells are essentially fibroblasts, and they retain the fibril-forming properties of that type of cell.

DISCUSSION.

Although the epiblastic hypothesis of the origin of the soft membranes is at variance with the usual teaching on the subject, it is very attractive. Before the work of Harvey and Burr came to my notice I had observed under the microscope that many specimens of leptomeningioma showed a papillomatous appearance such as is seen in frankly epithelial tumours. Moreover, the crushing of the central cells of a cell whorl (*see* p. 416) is analogous to the process which occurs in the centre of a cell-nest in an epithelioma. Further, were this hypothesis to be substantiated, such pathologically similar growths as leptomeningioma, neurofibroma of the nervus acusticus, and the tumours found in von Recklinghausen's disease could be traced to an identical ultimate origin—the cells of the neural crest. Indeed, cases have been reported in which both von Recklinghausen's disease and leptomeningioma of the spinal cord have been present in the same patient, and one such which came under my notice will be referred to later. So far as I am aware neurofibroma of the eighth nerve has not been described in conjunction with leptomeningioma, but the histological appearance of that tumour is compatible with an origin from cells of the nerve-sheath, themselves derived from neural crest cells. Moreover, the fact that fibril formation occurs in leptomeningiomas (*see* p. 412) is not to be adduced as proof of their mesodermal origin, for the transition from epithelial to connective-tissue type of cell may be traced in many tumours.

In brief, then, the epiblastic origin of the arachnoid is strongly supported by experimental evidence, and not only offers a feasible explanation of the characteristics of the leptomeningiomas, but also provides a reasonable basis for their classification with other related tumours.

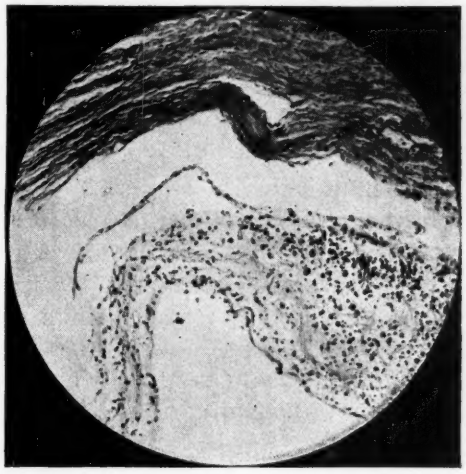


FIG. 226.—The figure shows, from above downward: dura mater; the 'membranous' part of the arachnoid separated from the remainder; and somewhat thickened spongy tissue between the arachnoid membrane and the spinal cord. From a case of leptomeningioma of the spinal cord. (× 50.)

IV. STRUCTURE AND RELATIONS OF ADULT LEPTOMENINX.

The fully developed arachnoid is a thin transparent membrane formed of bundles of fibroglia, collagen, and a few elastic fibrils, and covered on its surfaces by low cuboidal cells (*Fig.* 226). Its outer surface is closely applied and possibly adherent in places to the inner surface of the dura mater. Trabeculæ pass from its inner surface across the relatively wide space separating it from the 'pia mater',* and in the dorsal region form a distinct partition in the dorsal median line—the *septum medium posterius*.

* From every point of view a better term would be the *pial layer* of the leptomeninx.

The membrane furnishes a covering to the *ligamentum denticulatum* and to the segmental blood-vessels from the intercostal arteries, which cross the canal to the cord. But of greatest importance for the present discussion is the arrangement of the arachnoid around the nerve-roots as they leave the spinal canal through the intervertebral foramina. Formerly it was thought that the membrane was continued for some distance along the issuing nerve-roots and finally blended with their perineurium. This conception has been disproved recently by the careful histological work of Elman, who found that it accompanies the nerve-roots, although not in actual contact with them, for only one or two millimetres; it is then reflected toward the cord, to become continuous with the covering of the roots, and finally to blend with the pial layer. The outer surface of the cul-de-sac so formed is in close contact with the inner surface of the funnel of dura as this passes to contribute to the nerve-sheath. Thus there is no direct communication between the subarachnoid and perineural spaces. (Nevertheless after an injection of lipiodol (*see* p. 450) into the cisterna magna, I have seen globules of this substance in positions corresponding to the courses of intercostal nerves.)

As the individual grows older the cells forming the covering of the arachnoid undergo localized hyperplasia in certain situations, and of these the most important are the angles formed by the membrane at its points of reflection upon the nerve-roots. Here they form clusters with pale, rather more rounded nuclei and cytoplasm which takes on the acid stain but poorly.* In certain of these clusters a process of condensation appears to take place, which results in a smaller type of cell with a nucleus richer in chromatin. These cell masses are closely applied to the dura, and often are prolonged actually into its stroma.

Such thickenings of the covering cells are found scattered irregularly over the membrane, the greatest number being situated on its dorsal aspect. These aggregations are of two types; in the first type there is a gradual transition into the normal thickness of the covering layer, while in the second type the mass is, as it were, heaped on the surface of the membrane. Histologically the cells forming these clusters are similar to those found at the intervertebral culs-de-sac; in general the cell outlines are less defined, and there is some tendency to whorl formation.

In the majority of cases these clusters of cells seem to be merely an expression of the advancing age of the individual, and may be regarded as physiological. However, the arachnoid cells undergo a similar hyperplasia under the influence of certain stimuli (*Figs.* 227–229). Thus in the presence of infection or of a foreign body there occur localized increases in the number of layers of lining cells, and those on the surface may be cast off to become actively phagocytic. When the stimulus becomes non-operative the surface layers may not return to their normal thickness, and in this way a second category of cell cluster arises. As will be discussed later, this process may be the connecting link between localized trauma to the spinal column and the

* The histological descriptions in this and the following paragraph should be compared with that of the leptomeningiomas.

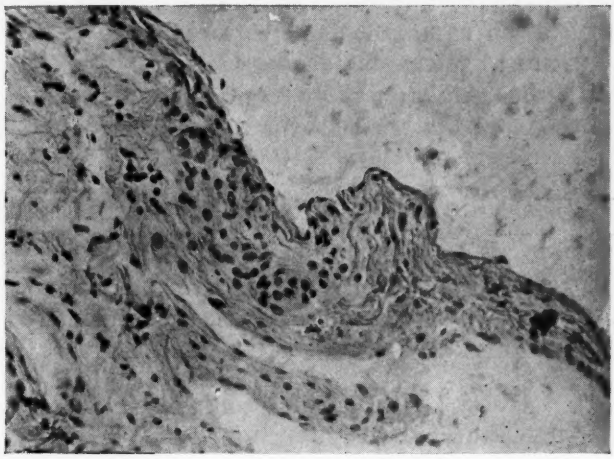


FIG. 227.—From a case of chronic spinal arachnoiditis. The section passes through two cell clusters, which taper at their ends. Numerous smaller and more darkly staining nuclei are seen throughout the main mass. On the right an irregular deposit of calcium is present. (× 140.)

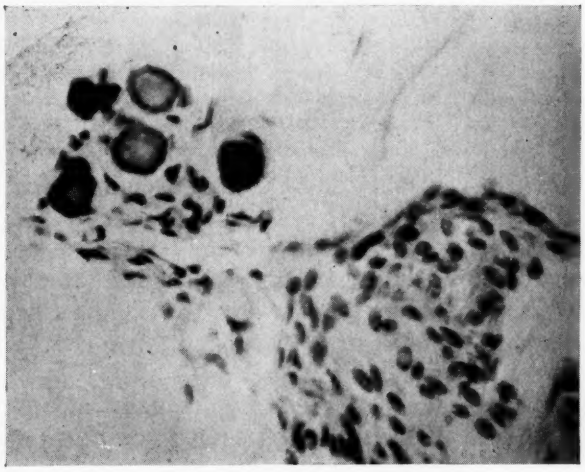


FIG. 228.—From a case of chronic spinal arachnoiditis. The section passes through a 'heaped-up' cell cluster. Note the pale rounded or oval nuclei, with little chromatin. Toward the upper free edge of the cluster the nuclei are smaller and stain more darkly, and smaller cells of the same type are present regularly throughout the mass. On the left are seen five 'sand bodies' which have formed in an older cluster. (× 350.)

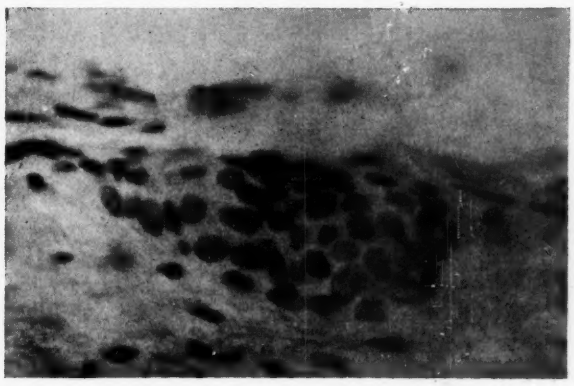


FIG. 229.—A similar cell cluster, showing the tendency to whorl formation. From a case of chronic spinal arachnoiditis. (× 500.)

development of a leptomeningioma. Usually, however, the aggregations grow very slowly, as is reflected by the absence of mitotic figures in them. They are prone to calcareous degeneration, which may proceed to the formation of sand bodies similar to those found in the tumours under discussion (*see* p. 417). The stages in this process will be described later.

V. INCIDENCE OF LEPTOMENINGIOMAS.

In a series of 35,000 autopsies Schlesinger found spinal-cord tumours in 0·43 per cent of cases, and this figure represented 2·06 per cent of the total number of tumours. In 400 cases of such growths collected by the same observer the distribution was as under:—

Table I.—Relative Incidence of all Spinal-cord Tumours.

	Cases	
Sarcoma	107	
Tuberculoma	64	
Echinococcus cysts	44	
Neurofibroma	37	
Gumma	28	
Glioma and gliosarcoma	27	
Myxoma	11	
Lipoma	11	
Miscellaneous	47	
Psammoma and endothelioma ..	24,	or 6 per cent of the total number.

Frazier, on analysing a collected series of 330 tumours, found endotheliomas (25) and psammomas (13) in 38 cases, or 11·5 per cent of the total.

There appears to be a tendency to affect the female sex; the series under review contains 40 females (66·7 per cent) and 20 males (33·3 per cent), while in Frazier's collected series of similar growths females were affected in 26 cases (70·3 per cent) and males in 11 cases (29·7 per cent); in one case in the latter series the sex was not stated.

Those in the middle and later decades of life are principally affected: thus the age distribution in the cases which form the basis of this paper was as follows:—

Table II.—Age Incidence of Leptomeningiomas.

Age	Cases
0–10	0
10–20	1
20–30	5
30–40	18
40–50	11
50–60	19
60–70	5
70–80	0
Not stated	1
	60

Such a table displaces the incidence to a slightly later age, since in many cases the symptoms of which the patient complained had been present for years before operation.

VI. OCCURRENCE WITH OTHER TUMOURS.

There are on record cases in which a patient has suffered from peripheral nerve tumours of the type described by von Recklinghausen as well as from leptomeningioma of the central nervous system. I have had the opportunity of examining such a patient, who possibly had a tumour of the left eighth nerve also (*see* p. 401).

Mr. B. P., age 20 years, first came under observation at the Mayo Clinic on April 8, 1920.

History.—He complained of bulging of the left eye, and of difficulty in walking and using his hands. At that time the following peripheral nodules were present: Two under the skin of the right antecubital fossa; one in the left ulnar nerve behind the inner epicondyle of the humerus; one near the inner head of the left gastrocnemius; one over the fibula in the left external popliteal nerve. No tumours of the skin were present.

Neurological Examination.—This disclosed: (1) Evidence of compression of the spinal cord at the level of the tenth dorsal segment; (2) Evidence of a tumour pressing on the left optic nerve in the orbital cavity; (3) ? Evidence of pressure upon the left eighth nerve; (4) Evidence of impairment of the function of the left ulnar nerve below the elbow.

Operations.—The patient underwent the following operations: (1) Excision of the nodules in the right antecubital fossa. Pathological diagnosis, *neurofibroma*. (2) Removal of tumour of the left orbital cavity, with the left optic nerve. Pathological diagnosis, *endothelio-psammoma*. (3) Laminectomy and removal of dorsolateral tumour opposite the seventh and eighth dorsal vertebræ. Pathological diagnosis, *endothelio-psammoma*. (4) Removal of nodules from left ulnar nerve and left calf. Pathological diagnosis, *neurofibroma*.

Subsequent History.—In October, 1921, the patient was walking well and had developed no new symptoms. In February, 1922, he developed hoarseness. In February, 1924, he had a convulsion while asleep, and began to suffer from occipital headache. In March, 1924, he had another convulsion. This was preceded by an aura—pain in the region of the left eye passing to the right eye, and movement of the head and right eye to the right. By April, 1924, the convulsions were accompanied by aphasia, motor and (?) auditory. Attacks of petit mal were also present; these occurred two to three hours before a major attack.

When seen late in 1924 there was unmistakable evidence of progress of the disease. Thus he had occasional rapid fine jerks of the right hand, accompanied by tingling in the fourth and fifth fingers, and difficulty in finding the words he wanted to use. The left vocal cord was paralysed, and ophthalmoscopic examination showed bilateral choked discs of two to three dioptres. Additional peripheral nodules had appeared: (1) At the left angle of the lower jaw; (2) In the left sixth intercostal space in the nipple line; (3) In the right popliteal fossa.

In view of the nature of the case Dr. A. W. Adson felt he could not advise further surgical treatment.

The significance of such cases lies in the evidence they provide of a common origin for both types of tumour.

VII. PATHOLOGICAL ANATOMY.

Before the levels of the cord affected by leptomeningiomas are presented, brief reference may be made to the topographical classification of spinal-cord tumours in general. Thus they may be divided into: (1) Extradural tumours: (*a*) arising in the arches, (*b*) arising in the bodies, (*c*) arising in extradural fat. (2) Intradural tumours: (*a*) extramedullary, (*b*) intramedullary. These situations are shown in ***Fig.* 230.**

Leptomeningiomas are always intradural extramedullary tumours. This fact supports the view that they take their origin from the arachnoid; for although they are never extradural in position, yet the outermost cells of the dura, where it is separate from the bony canal, present the same histological appearance as those upon its inner surface; and the latter have been supposed to give rise to these growths.

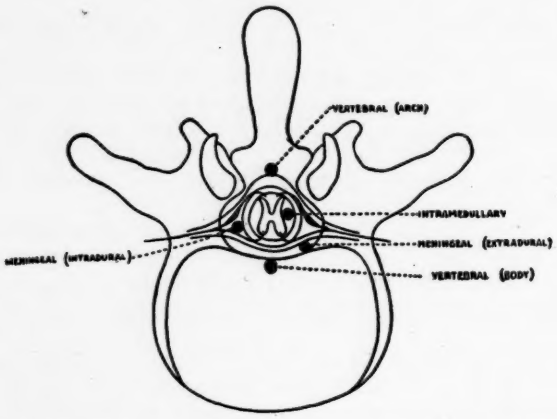


FIG. 230.—Diagram to indicate the various points of origin of tumours of the spinal cord, membranes, and vertebræ. Horizontal plane.

(*From Dr. Frazier's monograph.*)

Of all the cases of intradural extramedullary tumours treated at the Mayo Clinic, leptomeningiomas comprise 55·7 per cent. They are most common in the dorsal region of the cord—an incidence no doubt partly due to the greater number of segments in this portion. Thus in the series under review the relative frequency was:—

Table III.—LEVEL INCIDENCE OF LEPTOMENINGIOMAS.*

	PER CENT
Cervical cord	13·3
Dorsal cord	63·4
Lumbosacral and caudal	23·3

* Where the level was given in terms of bony points, this has been reduced to terms of segmental level.

Potel and Veaudeau, as quoted by Frazier, give the figures for all spinal-cord tumours as:—

Table IV.—LEVEL INCIDENCE OF ALL SPINAL-CORD TUMOURS.

	PER CENT
Cervical cord	20·0
Dorsal cord	52·0
Lumbosacral and caudal	28·0

Intradural extramedullary tumours may be still further subdivided according to their situation relative to the circumference of the spinal cord. Thus a growth may be: (1) *Posterior*, behind the posterior nerve-roots; (2) *Posterolateral*, behind the dentate ligament and in front of the posterior nerve-roots; (3) *Anterolateral*, behind the anterior nerve-roots and in front of the dentate ligament; (4) *Anterior or ventral*, in front of the anterior nerve-roots.

In *Table V* is shown the relative incidence of the four types in the present series; for comparison, the same information with regard to all intradural extramedullary tumours collected by Frazier is also tabulated.

Table V.—Incidence of Tumours in Relation to the Circumference of the Spinal Cord.

Sources	Anterior		Antero-lateral		Posterior		Postero-lateral		Not Stated		Total	
	No.	Per cent	No.	Per cent	No.	Per cent	No.	Per cent	No.	Per cent	No.	Per cent
Learmonth .. (collected)	1	1·7	11	19·3	7	12·3	38	66·7	0	0	57*	100
Frazier .. (collected)	6	7·2	9	10·8	31	37·3	31	37·3	6	7·4	83	100

* Excluding three diffuse caudal tumours.

VIII. ETIOLOGY.

Like that of all neoplasms, the etiology of leptomeningiomas is obscure. Increasing age, with its concomitant variations in the physiological activity of the arachnoid itself, is undoubtedly a factor. Cushing considers that the occurrence of these tumours within the skull may be due to herniations of the arachnoid, as a result of such long-continued increase in intracranial pressure as may be found in patients suffering from arteriosclerosis. In a certain proportion of the cases under review the blood-pressure has been recorded, and occasionally the optic fundi have been examined. A study of the findings does not reveal any marked deviation from the normal; so far as spinal leptomeningiomas are concerned, arteriosclerosis may be disregarded as a factor contributing to their origin.

With regard to the part played by trauma in initiating such a growth, attention has been drawn to localized hyperplasia of the cells covering the arachnoid, in their efforts to deal with the products of an injury. In but 3 of the 60 cases considered here was there a history of trauma. The data are shown in the following table:—

Table VI.—Data in Cases in which Trauma Preceded the Appearance of Leptomeningiomas.

Age	Sex	Interval between Blow and Onset of Symptoms	Site of Blow	Segmental Level of Tumour
29	F	2 years (but continuous slight diffuse backache since blow)	Lower back	D 12
57	F	1 year	Lower back	C 7 – D 3
25	M	8 years	Interscapular	C 1 – C 4

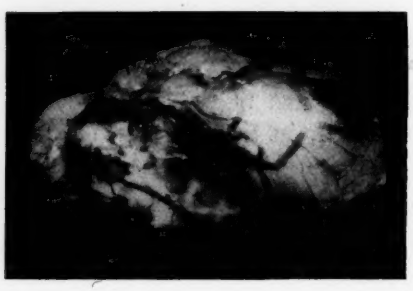
In one of the cases, therefore, there was a definite relationship between the level of the blow and the level of development of the tumour—an 'endothelioma' which partly encircled the cord. In Oustianol's case a similar relationship existed between the injury and the growth, here a 'psammoma'. While the evidence in support of the traumatic theory is meagre it cannot be ignored. Moreover, symptoms due to the tumour have often lasted so long

that a previous injury, perhaps slight, is not prominent in the mind of the patient, and unless closely questioned he may not include this point in his story.

In the course of a laminectomy for cord tumour it is not uncommon to discover evidence of chronic inflammation in the leptomeninx, and especially in its parietal layer. This takes the form of opaque local thickenings and sometimes of small cysts. Histologically the thickenings are seen to be made up of masses of arachnoid cells such as have been described (p. 402). There is an established relationship between chronic inflammation and tumour growth, and it is more than possible that one such thickening may become the starting-point of a tumour. Certainly the structural similarity between the two types of lesion is very suggestive.

IX. GROSS PATHOLOGY.

Usually the tumour has the shape of a cylinder with rounded ends, although when it is small, spherical or hemispherical forms are encountered (*Figs.* 231, 232). Since lateral expansion must occur for the most part within a limited lumen the outer and inner surfaces of the growth are commonly somewhat flattened. When the tumour extends beyond the limits of the spinal canal it has an irregular shape. Its contour is somewhat nodular, and



FIGS. 231, 232. — Leptomeningiomas after removal by operation. Note the bluntly cylindrical shape, the nodular contour, and the capsule with its blood-vessels. The scale on *Fig.* 231 is in centimetres.

its consistency varies from a moderate degree of firmness in the more cellular types to extreme hardness in those specimens which have undergone extensive calcareous degeneration. A definite capsule is always present, and this has a grey or greyish-blue colour.

The size of the growth varies within wide limits; it is greatest in the cervical region and in the region of the cauda equina. One tumour in the Mayo Clinic series, occurring in the latter situation, measured 20·00 cm. in length, and reached from the level of the tenth dorsal vertebra to that of the fifth lumbar vertebra. Neuhof reports a specimen from the cervical region

in which the upper pole of the tumour was beneath the arch of the atlas, while the lower pole was at the level of the first dorsal spine. Commonly the growth is from 20 mm. to 35 mm. long, from 10 mm. to 20 mm. in its broader axis, and from 10 mm. to 15 mm. in its flattened axis.

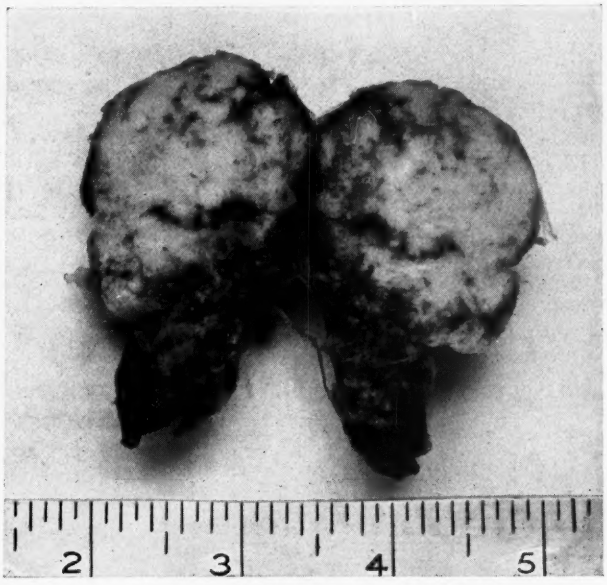


FIG. 233.—Section through leptomeningioma removed at operation. Note the hæmorrhagic cavity at the lower pole of the growth, which has a 'lobulated' appearance. The scale is in centimetres.

On section the surface of the neoplasm has usually a dull greyish-white appearance (*Figs.* 233, 234). If many sand bodies are present, the knife encounters gritty material, and the surface is speckled. It is rare to note any blood. In isolated cases where the tumour is large, areas of necrosis may be found, and such degeneration may go on to the formation of cystic cavities containing a faintly blood-stained or yellowish fluid.

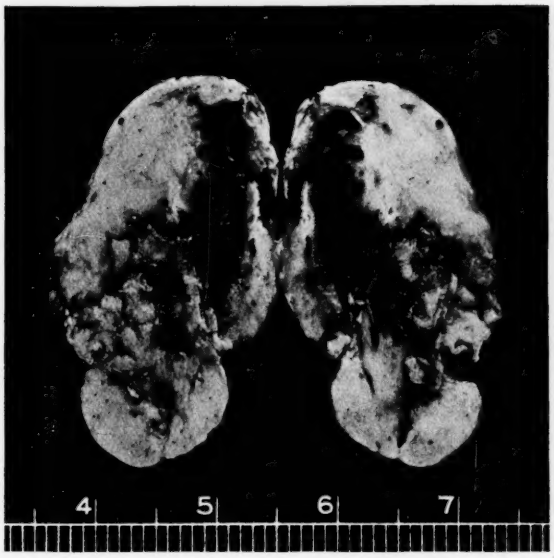


FIG. 234.—Section through a rather more cellular leptomeningioma. The scale is in centimetres.

In the majority of cases the outer surface of the neoplasm is adherent to the dura mater (*Fig.* 235), from whose inner surface fine strands of fibrous tissue pass to form part of the stroma of the tumour. Thus, where possible, adherent dura is removed with the growth in order to avoid leaving islands of tumour cells in the dural substance. A leptomeningioma may be so intimately attached to a nerve-root that this must be sacrificed to ensure complete removal (*Fig.* 236). Occasionally, when its origin is from the arachnoid in the region of an intervertebral foramen, the growth is so unattached elsewhere that there is no need either to remove dura or to open the subarachnoid space (*Fig.* 237). More rarely the tumour springs from the neural surface of the

arachnoid membrane, or from the pial layer of the soft membranes: the subarachnoid space must then be opened before extirpation can be started. With the exception of the dura mater as a rule the tumour does not infiltrate surrounding structures, although in one of the cases which I observed it was so intimately applied to the cervical cord that no accurate line of demarcation could be identified at

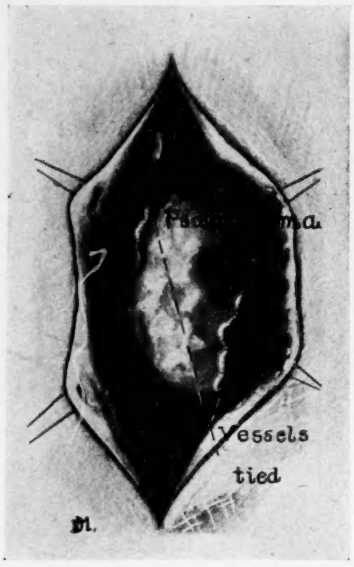


FIG. 235.—Showing, on right, adherence of tumour to dura mater, vessels from which are ramifying over the capsule of the growth.

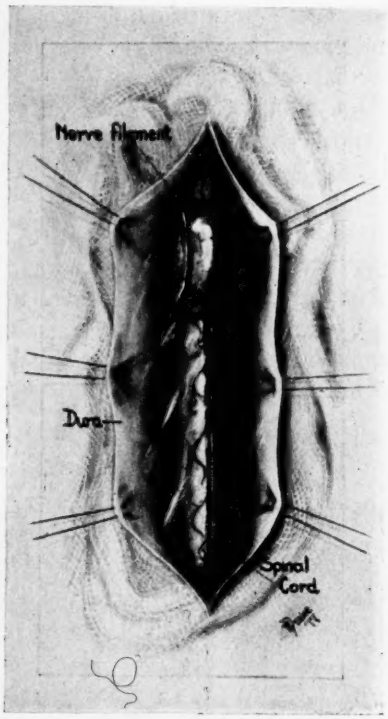


FIG. 236.—Showing intimate association of a posterior nerve-root with a dorsally situated leptomeningioma.

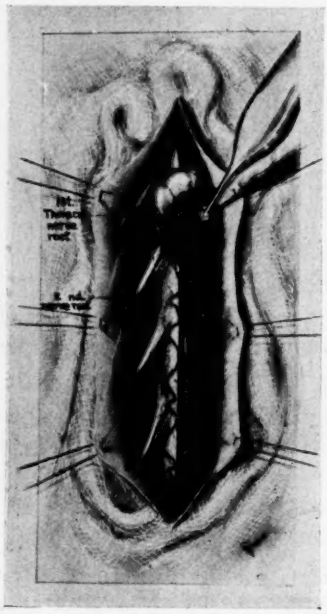


FIG. 237.—Showing general relations of a posterolateral growth. This is the commonest position of leptomeningiomas relative to the cord.

operation; and such a condition is not unique. The absence of infiltrative capacity shown by these tumours when occurring in the cord is a very remarkable characteristic, in view of the frequency with which cranial 'endotheliomas' not only penetrate the calvarium (thereby giving rise to hyperplastic exostoses), but also invade the muscles overlying it—for example, the temporal. Recurrence does not take place after thorough removal; in one case in this series the patient underwent a second laminectomy at a later date:

no new tumour growth was found. I do not know of any case in which metastasis has been demonstrated, although this has been described in a case of 'endothelioma' of the brain.*

When situated high in the cervical region a tumour may extend through the foramen magnum into the posterior fossa of the skull. In these circumstances it may give rise to symptoms both of increased intracranial pressure and of pressure upon the medulla (*see* p. 434). When arising in the vicinity of an intervertebral foramen it may extend through this opening.

X. MICROSCOPIC APPEARANCES.

The following description is based upon the examination of 31 spinal leptomeningiomas removed in the Mayo Clinic. In the majority of cases a number of sections from different areas of each tumour was examined. The following stains were used: Eosin and methylene blue; hæmatoxylin (Harris) and eosin; Mallory's phosphotungstic acid hæmatoxylin; Mallory's aniline blue stain for collagen fibres; Weigert's resorcin-fuchsin stain for elastic fibres; Lugol's iodine.

Cells. — As a general rule the proper cells of a leptomeningioma are somewhat flattened, although their shape varies with the general configuration of the tumour. There is often a tendency to progressive compression and elongation, so that the cell becomes spindle-shaped (*Fig.* 238). In many specimens, and particularly in the more cellular forms, the cells are so arranged that their nuclei show the appearance known as 'palisading' (*Fig.* 239), and in such areas the earliest stages of the process of compression may be studied. Again, in the vicinity of the dura there is frequently an alveolar arrangement of the cells (*Fig.* 240), which in these circumstances are somewhat cylindrical in shape.

FIG. 238.—Section showing the general appearance of leptomeningioma. On the right side is a well-formed capsule. Cellular areas, whorls, and sand bodies make up the bulk of the tumour. (× 60.)

The nucleus is small in proportion to the amount of cytoplasm. Its shape is influenced by the degree of crowding together of the tumour tissue; rounded in the cylindrical forms of cell, it becomes oval and later elongated as the cell is compressed. While it maintains a well-defined outline it is pale

* By Klebs; the secondary nodules were in the lung.

and poor in chromatin ; this is arranged in very fine strands upon which may be seen several small nucleoli (*Figs.* 241, 242). Occasionally a giant cell may be found (*Fig.* 243). It is rare to observe mitosis in these tumours, although it may be demonstrated in younger more cellular specimens if the tissue has been fixed in thin slices immediately on removal.

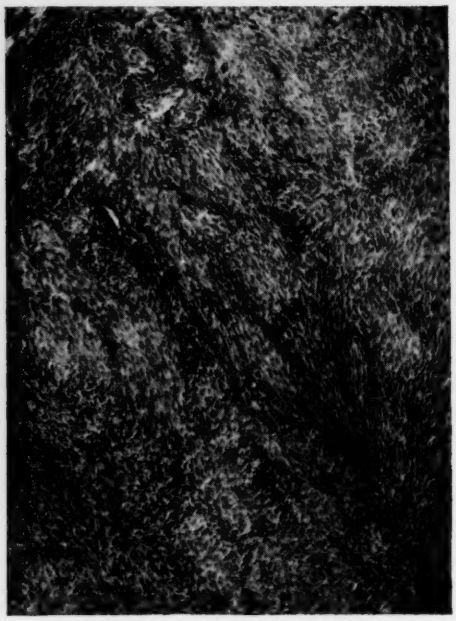


FIG. 239.—Cellular area of a leptomeningioma, showing the arrangement of the nuclei termed 'palisading'. (× 60.)

When—as is often the case—the cells of the tumour are concentrically disposed, both cytoplasm and nucleus conform in outline to a segment of a circle. In the more cellular types demarcation between individual cells is relatively less marked, and the cytoplasm stains poorly. In older tumours the cytoplasm takes on an acid stain more readily, and is non-granular.

Stroma.—The amount of stroma present varies inversely with the cellularity of the growth, to a certain extent with its age, and with its proximity to the dura. The stroma consists of a network of fibrils of several kinds which supports blood vessels with well-developed walls. As will be pointed out later, it is in part the result of the activity of the tumour cells themselves, and in part may be contributed by invaded dura mater. Infiltration by mononuclear leucocytes is often a striking feature of this framework.

Fibroglia Fibrils. — These may be demonstrated by staining with Mallory's phosphotungstic acid hæmatoxylin, which imparts to them a delicate blue colour. They are produced by the activity of the tumour cells, around which they form a delicate meshwork. In course of time they coalesce and give rise to strands of more homogeneous fibrous tissue (*Fig.* 244).

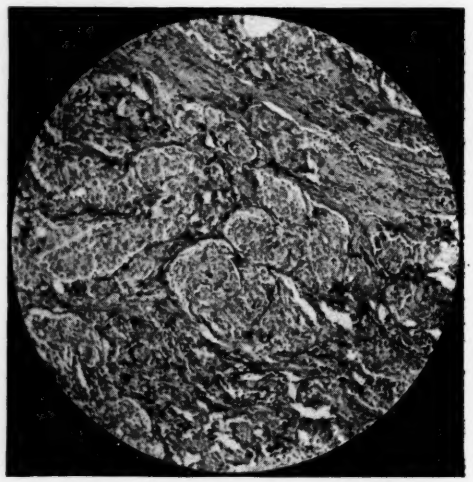


FIG. 240. — Showing alveolar arrangement of the cells of a leptomeningioma near the dura. (× 50.)

Collagen Fibrils. — These occur in older parts of a tumour, and are well demonstrated by Mallory's aniline blue stain. Counterstaining with eosin is best omitted, so that the fibres appear blue on an unstained

background. They are disposed in a network between the tumour cells (*Fig.* 245).

FIG. 241.—A typical cellular area. Note the pale nuclei, each with one or two nucleoli. They are rounded or oval in shape. The cell outlines are indistinct because the cytoplasm stains poorly. Here and there are irregular internuclear deposits of calcium. (× 500.)

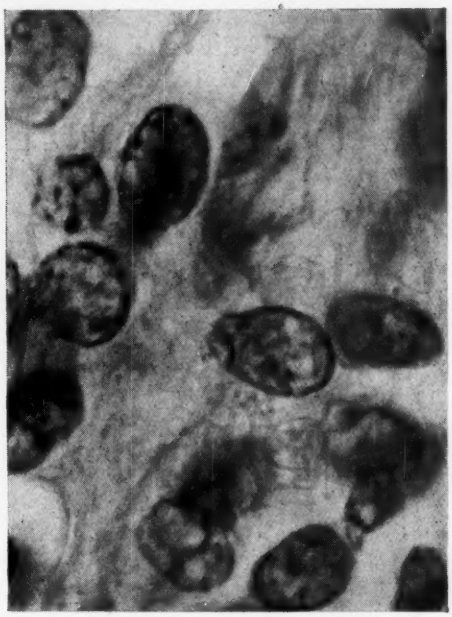


FIG. 242.—Type cells of leptomeningioma. The definite nuclear membrane gives a distinct outline to the nucleus. The scanty chromatin is arranged in a fine network, at the junctions of which it is here and there condensed to form rounded nucleoli. (× 1750.)

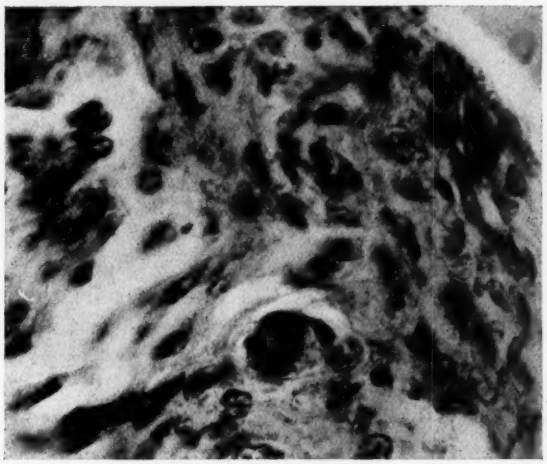


FIG. 243.—The section shows a giant cell. (× 400.)

Elastic Fibrils.—These may be stained by the resorcin-fuchsin stain of Weigert. They are most abundant in areas where progressive invasion of the dura mater is taking place. As mentioned above, they may be numerous in

the partitions of dural fibrous tissue, and they are also found to a limited extent between the tumour cells in the vicinity of these strands. These fibres appear to be the result of an increase in the amount of fibrous tissue normally found in the dura. A certain number of elastic fibres are also found in cellular areas of the neoplasm distant from this membrane (*see Fig.* 251), but these are not present in all tumours.* Oftentimes a cell-whorl contains elastic fibres.

While it appears established that extracellular fibrils of this type are laid down by the neoplastic cells, a considerable portion of the completed stroma is derived from two additional sources.

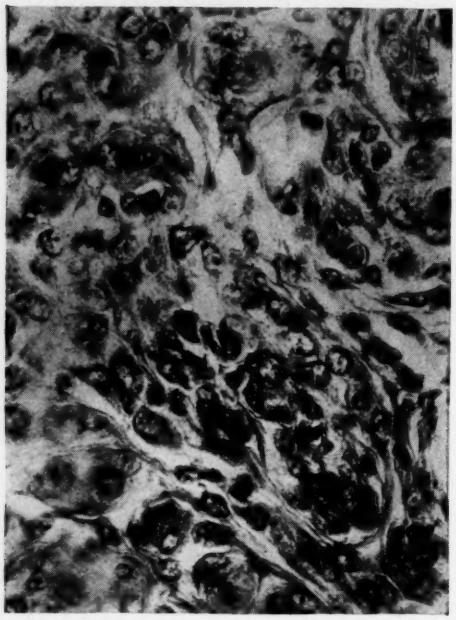


FIG. 244.—Fibrils of varying thickness are seen between the tumour cells. They are fibroglia fibrils stained by Mallory's phosphotungstic acid hæmatoxylin stain, and brought into prominence for the purposes of the photograph by the use of a suitable coloured screen. (× 400.)

FIG. 245.—Collagen fibres between the cells of a leptomeningioma. They are stained by Mallory's aniline blue stain, and brought into prominence for the purpose of the photograph by the use of a suitable coloured screen. (× 400.)

1. As a result of compression of the tumour cells themselves their cytoplasm becomes condensed and hyaline, and appears to be transformed into strands and whorls of fibrous tissue. The nuclei of these cells undergo karyo lysis (*Fig.* 246).

2. In the vicinity of the dura mater an infiltrating tumour is broken up by strands of adult fibrous tissue, which penetrate into its substance for varying distances. These strands are the result of hyperplasia of the dural

* I had the privilege of examining a preparation of Dr. Mallory's which showed much more elastic tissue than was present in any of the specimens at my disposal.

substance, are accompanied by blood-vessels, and oftentimes contain a considerable amount of elastic tissue (*Fig.* 247).

Cell-whorls. — The cells of a leptomeningioma show a remarkable tendency to form concentric whorls. These may be built up in a variety of ways, and are classified as cellular or fibrous.

Cellular Whorls. — The tumour cells may wrap themselves around some central cell or cells, around a blood-vessel (rarely), or around a calcareous granule. The size of the whorls thus formed varies from small collections of six or eight cells to large concentric bodies formed of many cells, but remains fairly constant for any one tumour. In the early stages of this process (*Fig.* 248) the central nuclei and cell bodies are still distinct from one another, but as the peripheral cells contract the

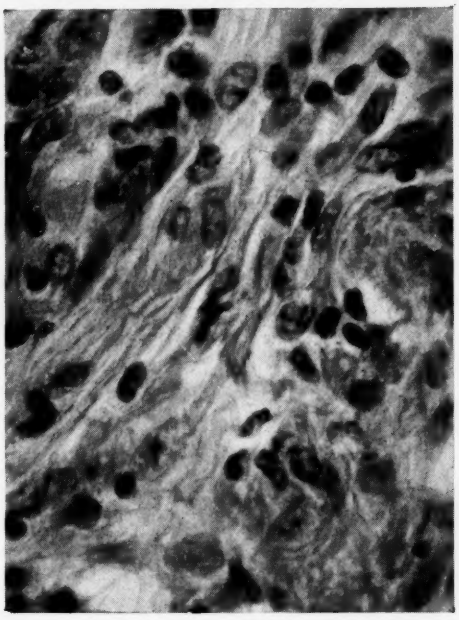


FIG. 246.—In the middle of the field is seen the process of gradual compression of tumour cells into fibrous tissue. (× 500.)

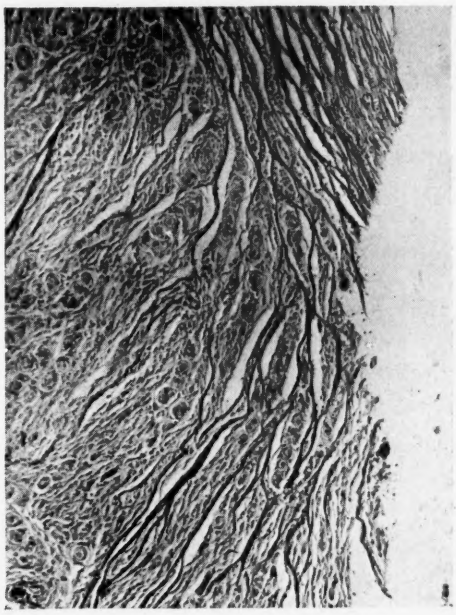


FIG. 247.—Section of a portion of tumour in the vicinity of the dura mater. Partitions of fibrous tissue directly continuous with the dural stroma pass deeply into the growth to form part of its supporting tissue. Van Gieson's stain. (× 60.)

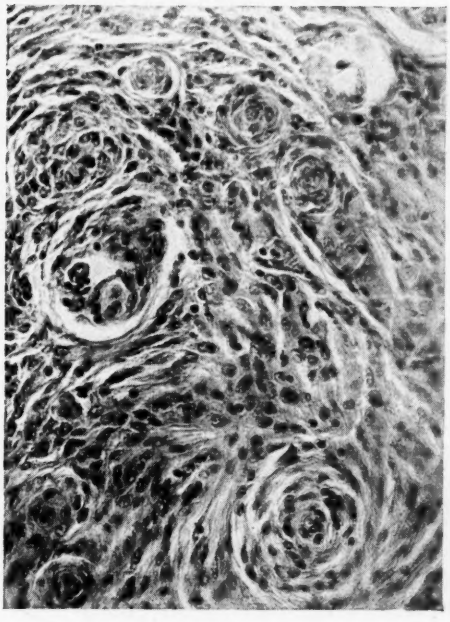


FIG. 248.—Cellular whorls. Note the concentric wrapping of the cells which produces a change in their shape ; thus the nuclei are becoming elongated. (× 150.)

core cells lose their outline and become more homogeneous, while their nuclei undergo karyorrhexis and later karyolysis (*Fig.* 249). The process may go on to a further stage, since the pressure of the outer cells may elongate and crush the cells of the more central layers, until the latter are directly converted into tissue indistinguishable from coarse hyaline fibrous tissue.

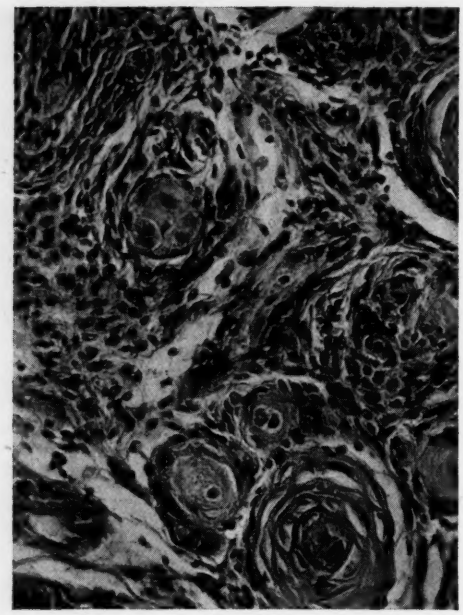


FIG. 249.—Cellular whorls, late stage. The nuclei which remain are much compressed, and are losing their distinctness. Many of the cells in the intermediate layers have been crushed into tissue indistinguishable from fibrous tissue. The nuclei of the cells in the outermost layers are still distinct. (× 150.)

Fibrous Whorls. — On the other hand, the nucleus or core of the whorl may be a strand of fibrous tissue, often dural in origin, around which the cells of the growth have disposed themselves concentrically. The core is thus amorphous from the first (*Fig.* 250). In the process of concentric wrapping the cells may include others already partly converted to fibrous tissue, so that in this type of whorl there is no regular gradation in their form from periphery to centre. Fibrous whorls oftentimes contain considerable amounts of collagen and elastic material (*Fig.* 251).

FIG. 250.—A congeries of fibrous whorls from a tumour which consisted largely of these. Note the concentric arrangement of the fibres and the absence of nuclei from even the outermost layers. (× 60.)

Blood-vessels.—The blood-vessels of the stroma are as a rule well supported, and especially in the neighbourhood of the dura mater may have a well-marked zone of elastic tissue in their middle coats. In older tumours not infrequently the lumen of the arteries becomes narrowed and even obliterated by hyaline degeneration of their walls (*Fig.* 252). The resulting malnutrition of the area supplied by the vessel may have a bearing upon the deposition of calcium in the tumour: though this hypothesis fails to account for the occurrence of sand bodies in the arachnoid itself—a membrane normally

devoid of vascular channels (Cushing and Weed). Moreover, the rare cases of cystic degeneration in leptomeningiomas may owe their occurrence to similar vascular changes. As has been mentioned, the perivascular tissues are often infiltrated by mononuclear cells.

Degeneration in Leptomeningiomas.—

Glycogenic Degeneration.—As is demonstrable in older tissues generally throughout the body, glycogenic degeneration may appear in those cells of the tumour which are ill-nourished or old. The degenerate substance is best demonstrated by staining freshly cut frozen sections with Lugol's solution, when brownish droplets or granules may be observed in the cytoplasm of such cells.

Hyaline Degeneration. — While hyaline degeneration is common in the walls of the blood-vessels it may be observed in the fibrous tissue stroma of the tumour also, and particularly in those areas formed by a process of condensation of the cells themselves. Such tissue is somewhat refractile, and stains intensely with eosin. Hyaline change also occurs regularly in the core cells of a whorl, where it is regarded by some as a stage essential to the deposition of calcium therein.

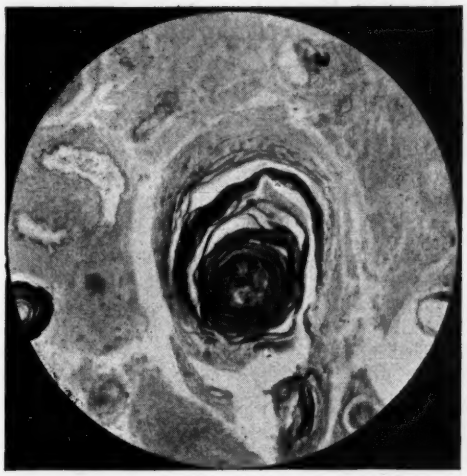


FIG. 251.—Showing fine elastic fibres in the outermost layers of a fibrous whorl. They are visible in the pale upper and outer part of the whorl as fine streaks ; the broad and dense black bands are infiltrated with calcium. One or two fine elastic fibres are also visible in the triangular cellular area at the edge of the field, below the whorl. (× 100.)

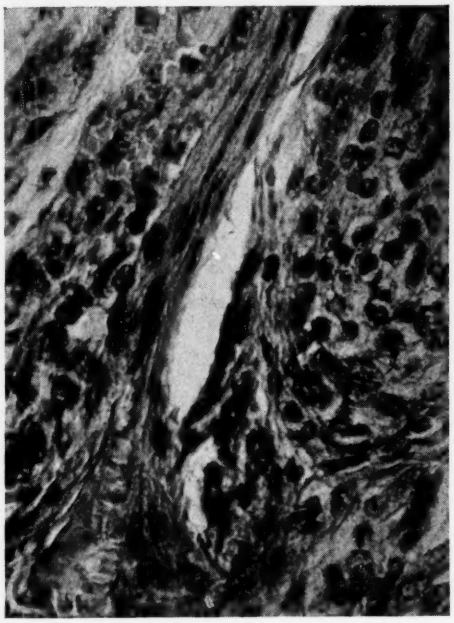


FIG. 252.—Hyaline degeneration in the wall of a blood-vessel in the substance of a leptomeningioma. Note the marked thickening of the vessel wall, and its homogeneous nature. (× 400.)

Calcareous Degeneration.—In the great majority of older leptomeningiomas microscopic examination discloses varying degrees of calcification. From the prominence of this process in the whorls, which leads to the formation of 'sand bodies', the term *psammoma* has been applied to this type of the neoplasm. However, calcification is not by any means confined to the whorls, and may occur widely throughout the tumour.

1. Calcareous granules may be seen in the nuclei of isolated cells, almost invariably at their periphery (*Fig.* 253), although ultimately the entire nucleus may be infiltrated. Such cells do not form part of a cell cluster.

2. Calcification also occurs in the intercellular substance and in the cytoplasm of isolated cells. The granules are usually small, and in the latter case show a marked relationship to the nuclear membrane (*Figs.* 241, 256).

3. When the whorls are affected, calcium may be deposited primarily either in the nuclei or in the hyaline intercellular substance. In the former case the first evidence of calcification is usually to be found in the form of granules situated immediately within the nuclear membrane. Thence the

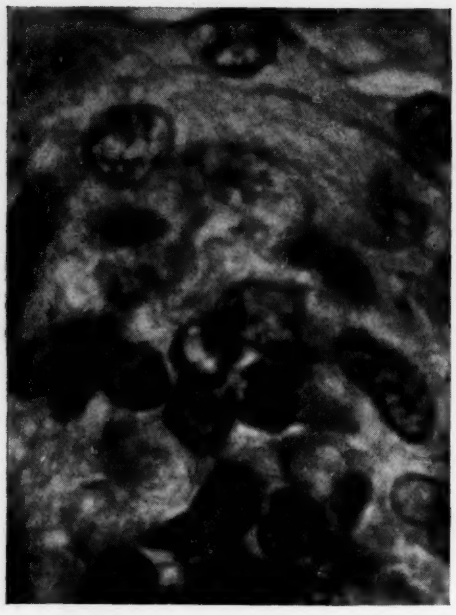


FIG. 253. — Calcification in nuclei. Darkly staining deposits of calcium are to be seen in certain of the nuclei. In most cases the granules abut upon the nuclear membrane, but in two the mineral matter shows as diffuse haze throughout the nuclear substance. (× 1750.)

FIG. 254.—Calcification in the intersubstance. The deposits are irregular in shape, and finely granular. They are present both in the tumour substance generally and in the whorls. The nucleus adjacent to the large deposit in the whorl on the right appears undamaged structurally, though it is compressed. The whorls are of the cellular type. (× 500.)

process extends diffusely or by the coalescence of several granules until the entire nucleus becomes calcified (*Fig.* 253). When the primary deposit is internuclear a prolonged retention of their outline by the surrounding nuclei is a remarkable feature of the picture (*Fig.* 254). Ultimately the entire whorl may become infiltrated with calcium salts. In sections stained with hæmatoxylin it then appears either as a round or nodular body of a uniform dark violet colour, or shows concentric lamination as if the mineral matter had been deposited in layers. All gradations in intensity of staining may be observed, according to the amount of calcareous matter present (*Fig.* 255). The differences are most marked in tumours containing a preponderance of

fibrous whorls; in sections stained with hæmatoxylin and eosin the appearance of these varies from a bright pink in unaffected whorls to an intense violet in the massively infiltrated sand bodies. Occasionally lighter and darker zones alternate, an appearance probably due to the occurrence of calcification in a whorl in which fibrous tissue has been irregularly enveloped by the tumour cells (*Fig.* 256).

The proportion of calcified to uncalcified tissue varies widely from tumour to tumour. Certain specimens become extensively calcified almost as fast as they grow; and this behaviour is not confined to examples occurring in older patients.* Others undergo calcification in older parts, but remain unaffected

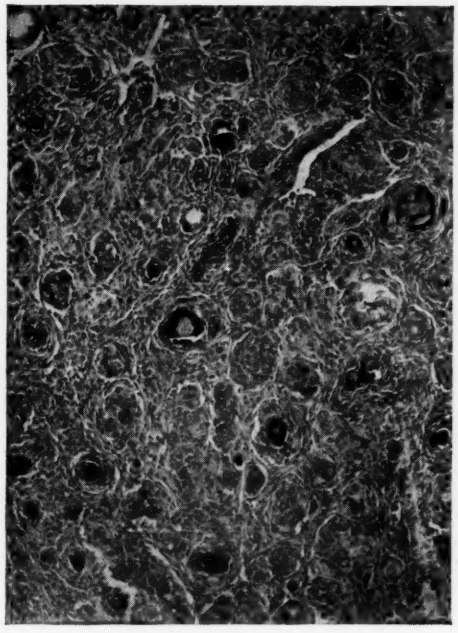


FIG. 255.—Variations in the amount of calcium deposits in cellular whorls. Note the different intensities with which the mineral matter stains in the different whorls. As a rule it is concentrically laid down, but in one or two whorls the areas of greatest density are irregular, and in a few the amount is uniformly great. (× 60.)

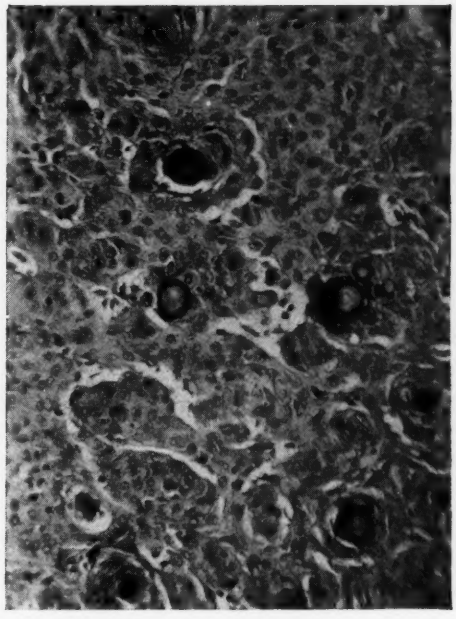


FIG. 256. — Spinal leptomeningioma. The section shows numerous sand bodies, which have undergone varying degrees of calcification. In the majority the mineral matter has been deposited concentrically. The whorls are of the cellular type. Calcification may also be seen in parts of the tumour other than sand bodies. It is both intra- and extracellular. (× 120.)

where they are growing. Still others seem to reach a certain size; then calcification begins, while the dimensions of the tumour remain stationary. The first type of growth, and the final stage of the third type, are aptly described by Bland-Sutton as 'dead' tumours. Possibly such differences are due to variations in the affinity of nuclei and cytoplasm for circulating calcium.

---

* The most completely calcified leptomeningioma I have seen was found post mortem in a lad, aged 22. It occupied the region of the velum interpositum.

XI. CLINICAL PHYSIOLOGY OF THE SPINAL CORD.

The nature of the initial symptoms and signs of the presence of a leptomeningioma, and their subsequent course, are so dependent upon the relation of the growth to the physiological construction of the spinal cord itself that a brief survey of this is germane to the subject (*Fig.* 257).

The pathological effects of the pressure exerted by a tumour may be described according to its position relative to the circumference of the cord. It is to be noted that since the majority of leptomeningiomas arise in the posterolateral region, symptoms referable to the function and distribution of the posterior roots are usually the first to appear. The pressure effects now to be explained are either superimposed upon, or occur subsequently to, those resulting from involvement of these structures.

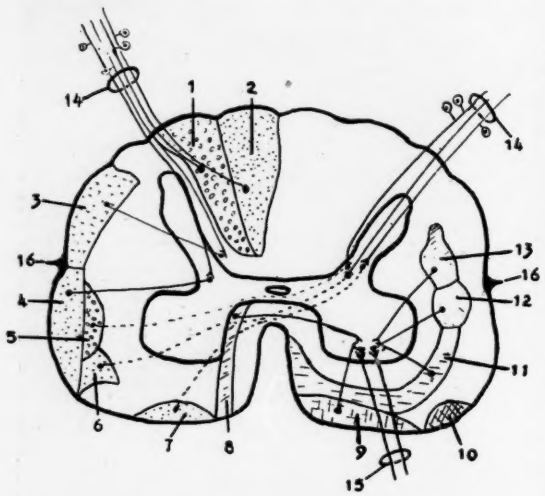


FIG. 257.—The conducting tracts of the spinal cord and their method of formation. Descending tracts on right of figure, ascending tracts on left (with direct pyramidal tract). 1, Column of Burdach; 2, Column of Goll; 3, Direct spinocerebellar tract; 4. Gower's tract; 5, Posterior spinothalamic tract; 6, Spinotectal tract; 7, Anterior spinothalamic tract; 8, Direct pyramidal tract; 9, Vestibulospinal tract; 10, Olivospinal tract; 11, Tectospinal tract; 12, Rubrospinal tract; 13. Crossed pyramidal tract; 14, Posterior nerve-roots; 15, Anterior nerve-roots; 16, Attachment of dentate ligament. (*Modified from Elliot-Smith.*)

Posterior Tumours.—These press first upon the conducting fibres in the columns of Goll and Burdach. These are formed from the centripetal parts of axones of bipolar cells in the spinal ganglia. After entering the cord, such a fibre divides into a long ascending branch, and a much shorter descending branch. The latter after a short course ends round a nerve-cell in the grey matter. The former passes upward on the homolateral side of the cord, and either ends at a higher level like the descending branch, or is continued to one of the nuclei in the medulla, whence its message is carried by a fresh neurone to the optic thalamus of the contralateral side; thence a third uncrossed neurone transmits the impulse to the cortex of the post-Rolandic area. Thus impulses carried by a certain proportion of these fibres rise into consciousness.

They are concerned with the transmission of the following types of sensation: (1) That part of tactile sensation which deals with the recognition of two separate points of contact. (2) Impulses from muscles and tendons communicating the degree of tension present in them. On these impulses depends the ability to appreciate differences in weight. (3) Impulses from articulations, communicating their position. (4) Impulses communicating the sensation of vibration.

Changes in their conductivity result in the following symptoms and signs

in areas of the same side supplied from below the level of the lesion: (1) Diminution or loss of appreciation of the compass test. (2 and 3) Incoordination in purposive movements of the limbs, usually ascribed to muscular weakness by the patient, including disturbances of gait of an ataxic type; astereognosis; loss of ability to appreciate differences of weight. (4) Diminution or loss of appreciation of a vibrating body.

Posterolateral Tumours.—These implicate the spinocerebellar tracts, posterior (or direct) and anterior (or Gower's tract). Both are composed of the axones of cells in the grey matter of the homolateral side, around which certain of the posterior root fibres of the same side have formed synapses. Both are destined to end in the vermis of the cerebellum, the former passing thither by way of the restiform body, the latter by way of the superior peduncle. Their function may be defined as the carriage of afferent impulses from the tissues under the skin, especially muscles and tendons; impulses which never rise into consciousness, but which are essential to the cerebellum for its task of maintaining muscular co-ordination and tone.

Interruption of these tracts therefore gives rise to varying degrees of inco-ordination in areas on the same side innervated by segments below the level of the lesion.

Anterolateral Tumours.—These may affect the conductivity of Gower's tract, with the clinical result set forth above; and at the same time, from implication of the more posterior of the anterior nerve-roots, there may occur certain associated signs referred to in the following paragraph.

Anterior Tumours.—These press upon the anterior nerve-roots. The resulting signs are found on the homolateral side, and are referable to the affected segment of the cord; at first irritative in character, they ultimately progress to muscular palsy and atrophy, and will be dealt with fully when the 'root cycle' is considered (p. 431).

All Tumours.—If not removed early, all tumours ultimately affect the more deeply situated tracts of the cord. For practical purposes these may be grouped thus: (1) *Ascending tracts* conveying impressions of pain, temperature, touch (except the discrimination of two points), and visceral sensation; (2) *Descending tracts*: (*a*) The *cerebrospinal tracts*, crossed and uncrossed; (*b*) Other descending tracts (*rubrospinal*, *vestibulospinal*, *tectospinal*) concerned in the maintenance of muscular co-ordination and tone, and visceral efferent tracts.

1. Ascending Tracts.—These are formed of the axones of cells in the grey matter of the contralateral posterior horn, around which have ended fibres of the contralateral posterior nerve-roots. These axones are so regrouped that sensations of pain and temperature are conveyed in the *posterior spinothalamic tract*, while sensations of touch (less tactile discrimination) and sensations of deep pressure are conveyed in the *anterior spinothalamic tract*. However, there is an important difference in the method of rearrangement of the two sets of fibres: both cross the cord obliquely, but the latter cross much more obliquely than the former. Purves-Stewart summarizes the matter thus: " There is no crossing of the fibres below the second lumbar segment. In the mid-dorsal region pain and temperature fibres cross quickly, and decussation is complete within one segment above the point of entry of the original posterior nerve

roots through which they entered the cord, whereas touch fibres cross more slowly, and are completely crossed in two segments. . . . In the upper dorsal region pain and temperature have crossed in two segments, and touch in three, whilst in the cervical enlargement the former cross in four segments, the latter in five. Finally in the upper cervical region pain and temperature ascend for five or six segments before they all reach the opposite side". This second neurone ends in the optic thalamus, whence uncrossed fibres continue the path to the post-Rolandic cortex.

Pressure upon these ascending tracts therefore leads to diminution or loss of appreciation of tactile (partially), thermal, and painful stimuli applied to the contralateral side in areas supplied by nerves arising below the level of the lesion. The probable path pursued by visceral afferent fibres will be indicated later.

2. Descending Tracts.—

a. Cerebrospinal Tracts.—These control the homolateral (crossed) and contralateral (uncrossed) sides of the cord, so that pressure upon them causes a diminution or loss of the ability to perform voluntary movements, below the level corresponding to the segment of the cord implicated. Since cerebral impulses regulating the degree of muscular tone also travel by way of these tracts, the paralysis is of the spastic type. In the upper three cervical segments, where these fasciculi are situated at or near the anterior surface of the cord, signs of pressure upon them may be the first and even the only indication of the presence of an extramedullary tumour.

b. Other Descending Tracts.—Lesions of the remaining descending tracts deprive the homolateral muscles supplied from below the level of the lesion of the co-ordinating impulses derived from the cerebellum (rubrospinal), visual apparatus (tectospinal), and semicircular canals (vestibulospinal). There follows also a loss of the tonic influences which they exercise.

In using such a brief summary of the conducting functions of the spinal cord to correlate clinical data, two most important qualifications must be borne in mind :—

1. Since the fibre tracts are not clearly demarcated, the signs and symptoms will almost always be those of involvement of several fasciculi. Moreover, while it is true that the effects of extramedullary pressure fall most severely upon tissue in the immediate vicinity of the growth, yet the pathological process is such that the more deeply situated bundles are also affected, albeit to a less extent.

2. Signs due to pressure on any part of the circumference of the cord may be accompanied by signs of pressure upon that area of the cord diametrically opposite to the original pressure point. In the succeeding section attention will be drawn to the mechanical factors underlying such a clinical picture (p. 428).

The Sympathetic System.—Clinical evidence of the interruption of tracts conveying sympathetic impulses may be found in variations in visceral sensibility, in the amount of cutaneous vasodilatation present, and in the amount of sweating.

Such fibres leave the cord from the eighth cervical to the second lumbar segment, both inclusive. They are said to be distributed as follows :—

Eighth cervical to third dorsal—all the body above that part of the thorax innervated by the cervical plexus.
Fourth dorsal to seventh dorsal—arms.
Eighth dorsal and ninth dorsal—trunk.
Tenth dorsal to second lumbar—legs.

Unilateral compression of the cord at or above the eighth cervical segment may therefore affect the whole homolateral side of the body, although the sensory loss is much less. At about the ninth or tenth dorsal segment the sympathetic and sensory levels coincide, while below this level the former is never so high as the latter.

The innervation of the bladder and rectum is so complicated that its consideration is best deferred until disturbances of these viscera are discussed.

XII. PATHOLOGY OF COMPRESSION OF THE SPINAL CORD.

The appearances due to compression of the spinal cord and the manner in which they are brought about have been exhaustively presented by Stewart and Riddoch, upon whose paper the following account is largely based. These observers emphasize the importance of the changes in the vascular supply of the cord produced by the compressing body. The lymphatic spaces around the segmental nerve-roots and blood-vessels communicate with the interpial lymph space, situated between the inner circular and outer longitudinal fibres of the pia mater. The interpial lymph space in its turn communicates with the lymph spaces of the cord, which are arranged in three groups (*Fig.* 258): (1) The *pericellular* lymph spaces, communicating with (2) The *perivascular* lymph spaces; (3) The *adventitial* lymph spaces, situated between the inner or middle coat of the vessels and their outer coat.

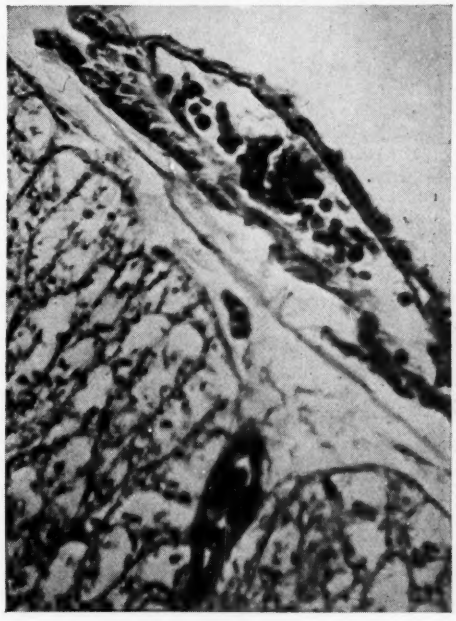


FIG. 258.—The section shows the intercommunication between the perivascular spaces of the vessels of the subarachnoid space, pia, and cord on the one hand, and the interpial space on the other hand. (× 350.)

The anterior spinal artery supplies the grey matter, and the two posterior spinal arteries the white matter of the cord. All are end arteries. If any one of these arteries is occluded by the pressure of the tumour or by thrombosis, the resulting damage to the nervous tissue of the cord is confined to the area supplied by the penetrating branches leaving the artery at the level involved. Below that level the circulation is maintained by anastomotic vessels derived from the intercostal, subcostal, and lumbar arteries, which reach the cord through

the intervertebral foramina. In the spinal veins the flow of blood is from below upward, and the collateral channels are few in number; therefore the veins below a growth are commonly found distended. This distention is an important contributory factor to the changes found in the cerebro-spinal fluid below the block; and, moreover, may possibly cause nervous symptoms referable to a segment below the tumour, not only as an effect of the venous stasis upon the nervous tissue, but also from the pressure exerted by the engorged vessels.

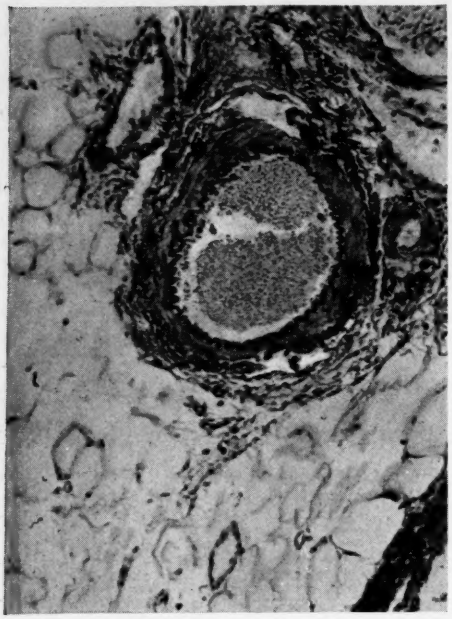


FIG. 259.—The meninges at the level of compression. The dura is thickened, as are also the walls of the blood-vessels. The perivascular tissue is infiltrated by small round cells. (× 90.)

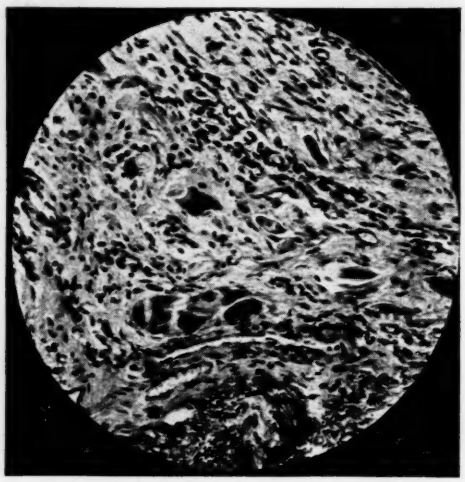


FIG. 260.—From a case of cervical leptomeningioma. Foreign body giant cells in the thickened spinal membranes at the level of the tumour. (× 100.)

FIG. 261.—Giant cell in the meshes of the arachnoid at the level of compression. It is of the foreign body type, and is in process of ingesting round cells and pigment granules. (× 400.)

The microscopic changes—surprisingly few save when the compression is of long standing—are grouped by Stewart and Riddoch under three heads: (1) *At the site of compression*; (2) *Below the site of compression*; (3) *Above the site of compression.*

1. At the Site of Compression.—

a. The spinal membranes are thickened, and the arachnoid contains giant cells engaged in the ingestion of blood-pigment (*Figs.* 259–261).

b. The endothelial cells lining the perivascular spaces are œdematous, and the lumen of the space contains small round cells and granules, sometimes

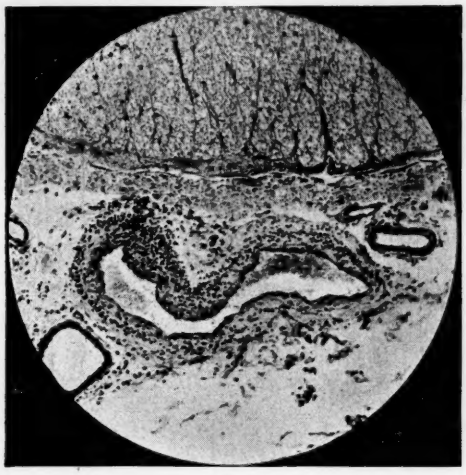


FIG. 262.—From a case of cervical leptomeningioma. Round cells in the Virchow-Robin space of a cord vessel, and also in the interpial lymph space. (× 50.)

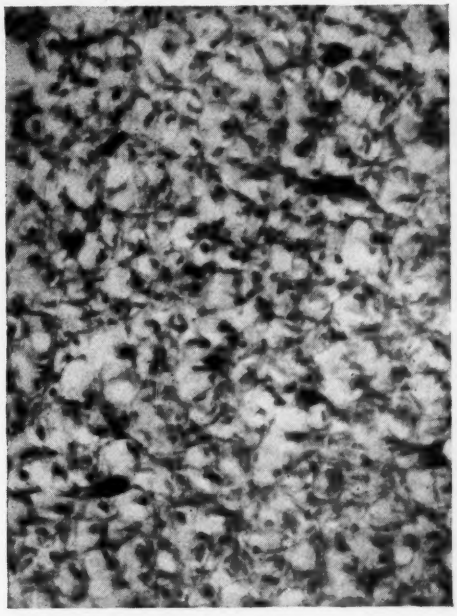


FIG. 264. — Gliosis in the posterior columns of the cord at the point of compression. (× 400.)

FIG. 263.—Round cells and granules in the interpial space at the level of compression of the cord. (× 400.)

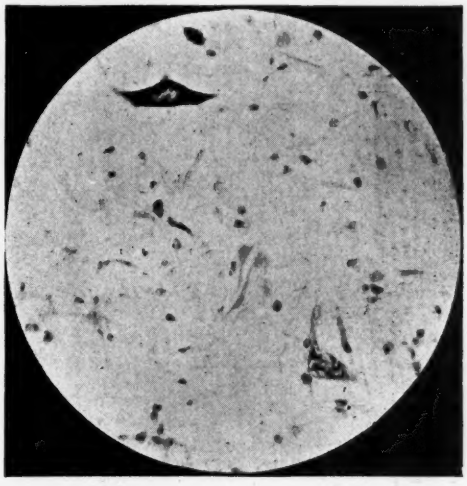


FIG. 265.—Motor cells from the anterior horn of the spinal cord of a dog, at the level of compression. The upper cell is unaffected, but the lower cell has lost most of its Nissl granules, and the nucleus is undergoing karyolysis. Methylene blue stain. (× 100.)

in such quantity as to obliterate the adventitial lymph space (Virchow-Robin space). (*Figs.* 262, 263.)

c. The nervous elements of the cord are separated by the proliferation of neuroglia, so that the section has a spongy appearance (*Fig.* 264).

d. In advanced cases there is necrosis of such areas of the cord as were supplied by arteries which have been occluded.

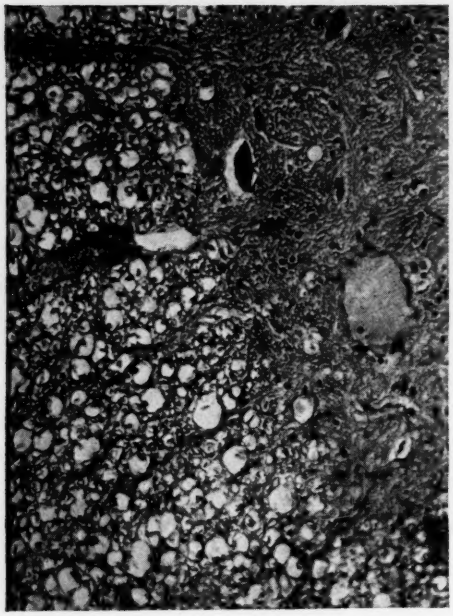


FIG. 266.—The section passes below the level of the compression and shows great distention of the blood-vessels of both grey and white matter, due to obstruction of the spinal veins. (× 150.)

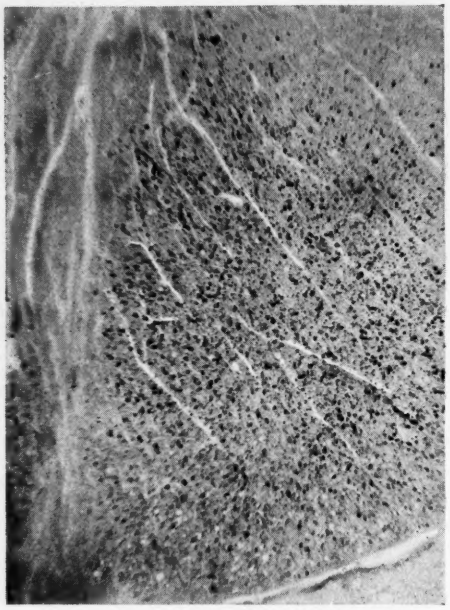


FIG. 267.—Cord from dorsal region in a case of leptomeningioma of the cervical region. Stained by Marchi's method. Note the degenerating fibres in the posterior column. (× 25.)

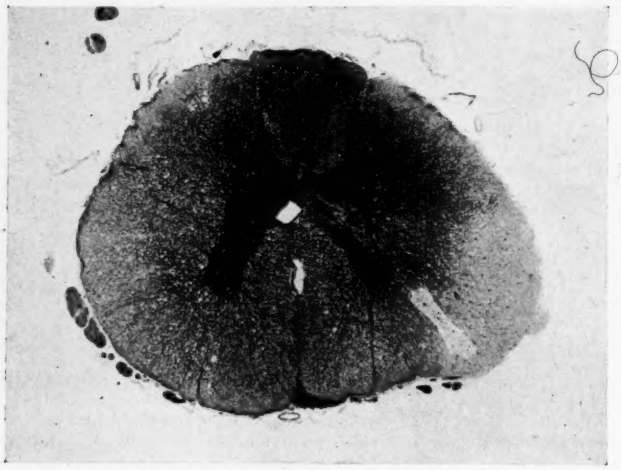


FIG. 268.—Early descending degeneration in spinal cord of dog, below point of compression. Although there was complete analgesia and partial paraplegia below the level of the tenth dorsal segment, degeneration is scanty and apparently selective. Weigert stain. (× 10.)

e. In the grey matter histological changes are first seen in the cells nearest the point of compression. They are swollen and their nuclei excentric. Later the nuclei lose their chromatin, and Nissl granules are no longer demonstrable (*Fig.* 265).

f. In the white matter the severity of the process is again greatest in the area nearest the tumour. The neuroglia proliferates, many of the axis cylinders are destroyed, and the myelin sheaths are swollen.

2. Below the Site of Compression.—

a. The veins are engorged and dilated. Their walls, and the walls of the arteries, are thickened (*Fig.* 266).

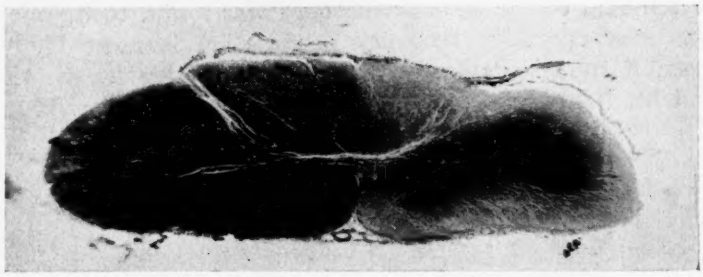


FIG. 269.—From a case of cervical leptomeningioma. Cervical cord immediately below tumour, showing unilateral descending degeneration. Weigert stain. (× 5.)

b. The lumen of the perivascular spaces does not contain small round cells or granules. Around the vessels of the cord there may be some proliferation of neuroglia.

c. Descending degeneration in the fibre tracts is scanty save in late cases, and out of all proportion to the clinical features (*Figs.* 267–270).

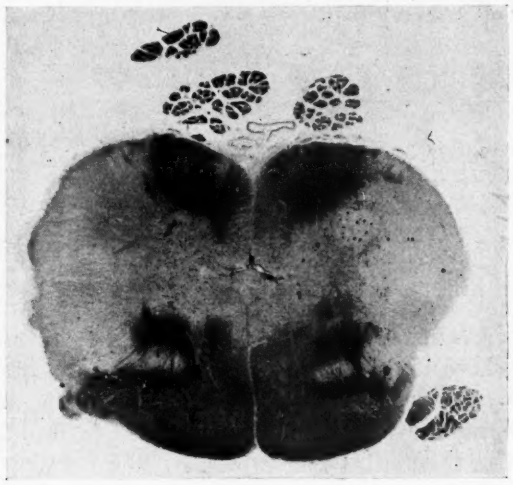


FIG. 270.—From a case of cervical leptomeningioma. Dorsal region of cord, showing advanced bilateral descending degeneration in the lateral columns. On the one side this has been produced by the pressure of the tumour, on the other by pressure of the cord against the opposite bony wall. Weigert stain. (× 5.)

3. Above the Site of Compression.—

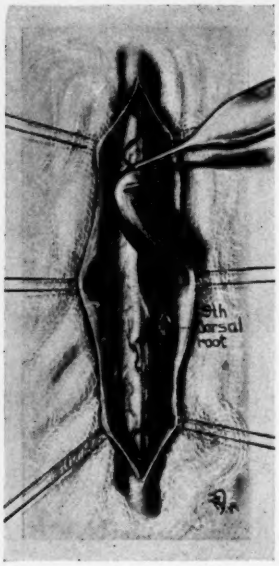
a. There is isolated degeneration of a few ascending fibres.

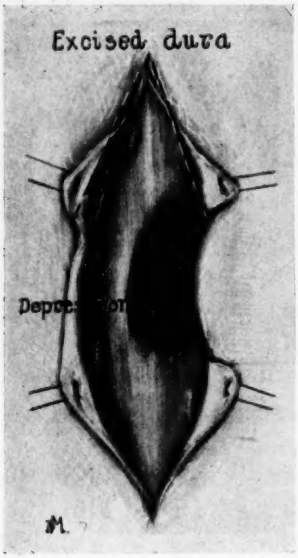
In the absence of sufficient degeneration in the fibre tracts to account for clinical symptoms, the only possible explanation of the latter is that the interruption is not an anatomical one, since the conducting paths may resume their function if the tumour is removed at a sufficiently early stage. According to Stewart and Riddoch, recovery of the conducting system is possible even after the fibres have lost their myelin sheaths; and function may return to motor cells in the anterior horns after they have become swollen and their nuclei excentric. The interruption is due: (1) To the pressure of the swollen blood-vessels upon the nervous elements; (2) To the pressure exerted by the exudate from the intramedullary blood-vessels

and lymphatics; (3) To malnutrition and deficient oxygenation of the tissues, partly because of the decreased permeability of the vessel walls, and partly because of the chronic congestion.

Where the pressure is long-continued the motor cells in the grey matter are the first permanently to lose their function. Where an artery has become blocked, permanent loss of function may also occur in its area of distribution.

The degree of compression of the cord varies; in one case in the present series, after removal of the tumour the cord was found to be one-sixth of its normal size. Post-operative recovery of function is more likely when the cord has been flattened gradually over a considerable length than when it has been indented deeply by a circumscribed growth (*Figs.* 271, 272).





FIGS. 271, 272.—Showing depressions in the cord produced by leptomeningiomas.

Mechanical Factors in Compression of the Cord.—Naturally the levels of the cord most sensitive to increases in extramedullary pressure are those where it cannot yield before the advancing tumour—that is, where it is fixed by the attachments of the dentate ligament to the dura mater. It follows that the levels of its greatest possible excursion are the points of origin of the segmental nerve-roots. The varying calibre of the spinal canal may also affect the rate at which symptoms develop; thus while relatively roomy in the cervical and lumbar regions, it is less so in the dorsal region. As pointed out by Elsberg and Stookey, mechanical factors may explain the cases of 'reversed Brown-Séquard syndrome' which occasionally occur (*Fig.* 270, and *see* p. 432). If the tumour is adherent to pia mater, the side of the cord opposite to it is, if the level permits, pushed against the adjacent bony wall; in the absence of such attachment the cerebrospinal fluid forms a cushion between the tumour and the cord, before which the latter is pressed against the bone or ligament opposite. As Elsberg and Stookey admit, the second

of these two explanations is difficult to reconcile with the laws of fluid pressure; yet some such process must be postulated to account for the clinical features. These hypotheses are supported by the observation that in certain cases the withdrawal of cerebrospinal fluid from that portion of the subarachnoid space below the tumour may lead to variations in the intensity and even in the level of the clinical signs. In such cases the removal of the buffer previously provided by the fluid permits the tumour to exercise the greatest pressure of which it is capable.

XIII. CLINICAL FEATURES.

The following description of the clinical features of cases of leptomeningioma of the cord is based upon a study of the case records of 31 patients treated at the Mayo Clinic, and 29 reported in the literature since the year 1918. Five of the former came under my personal observation, through the courtesy of Drs. W. D. Shelden and A. W. Adson, of the Neurological Department, and are described in full on pp. 462–469.

It has been customary to divide the course of the disease into three periods or 'cycles': (1) The root cycle; (2) The Brown-Séquard syndrome; (3) Complete paraplegia with urinary and rectal incontinence. While this is useful for descriptive purposes, it has the effect—common to all such artificial divisions—of obscuring the essential continuity of the manifestations of the disease. I prefer to regard its clinical features from the point of view of the pathological physiology and anatomy of the parts affected. While the majority of patients will probably first seek medical advice during the so-called root cycle, the nature of the pain from which they suffer is unfortunately rarely recognized at this stage. When the final diagnosis is made the patient shows features of both second and third periods, the diagnostic value of which can be appreciated only by a proper understanding of the processes concerned in their production. Moreover, since the symptoms vary according to the relation of the tumour to the spinal cord, no one description is applicable to all growths. That which follows will not be subdivided in any way.

There is wide variation in the duration of symptoms and signs from their onset until operation. In many cases such delay in exploring the cord is avoidable; in a very few, difficulties in determining the exact level of the growth force the clinician to wait until the course of the malady provides him with more complete information upon which to base his diagnosis. In the present series the average duration of the disease was 30·8 months; the shortest history given was 1·5 months (one case), and the longest 84 months (four cases).

The first symptom complained of is usually *pain*. In but six cases of the present series (10·0 per cent) was pain absent during the whole course of the disease. Three of these patients had anterolateral tumours, whose presence does not necessarily give rise to pain, while three suffered from posterolateral growths of small size, probably situated between two adjacent bundles of posterior nerve-roots. Pain is almost always due to pressure upon posterior nerve-roots, and since at the beginning only a few fibres are involved by the neoplasm it is often at first strictly localized to one place on the

surface of the body. Later, as more and more fibres become involved, the pain radiates along the nerves joined by the affected roots. It is at first unilateral, but may become bilateral where the tumour is extensive, or where the opposite posterior root is pressed against the bony wall of the spinal canal; and strictly dorsal growths may give rise to bilateral pain from the first. The pain is described in a variety of terms: aching, drawing, sharp, dull, gnawing, tight, cramping, stinging, and pricking. Sometimes it is continuous, sometimes it occurs in almost unbearable paroxysms, which may be separated by intervals of complete freedom. An attack may be precipitated or intensified by any sudden jarring movement, especially of the spine, or by coughing or sneezing; all these factors alter the relation between growth and fibres, the last two by causing a momentary increase in the fluid pressure in the subarachnoid space. Pain is often worst when the patient is recumbent, and is relieved by the assumption of an erect position. Thus a history may be given that the patient is awakened by pain after a few hours of sleep, and can obtain relief only by getting up and walking about; indeed, many discover for themselves that they pass the night most comfortably by sleeping in a sitting posture in a chair.*

At this stage it may be discovered that one spinous process is acutely tender; this belongs to the vertebra innervated by the segment opposite which the tumour is growing. More rarely it is possible to demonstrate some rigidity of the bony spine immediately over the tumour, a sign which results from direct irritation by the growing neoplasm. Root pain disappears as the disease progresses, when the synapse between root-fibre and nerve-cell of the second neurone becomes functionally paralysed, or when the conductivity of the second neurone is interrupted. Later in the disease there may develop pain which has a bizarre distribution. It is more than likely that this is the result of pressure upon the ascending tracts, a point which will be discussed later (p. 436).

While root pain is present, and even sooner, paræsthesiæ may be felt in the skin area supplied by the irritated roots over a period which may last for years. Occasionally a ventrolateral tumour first discloses its presence by giving rise to contralateral paræsthesiæ. In such a case the growth presses the opposite side of the cord against the wall of the canal, and in this way sensory tracts are irritated before their individual fibres have crossed the cord. The feeling most often complained of is numbness and coldness, but others, such as formication, burning, tingling, a sensation as of wool upon the skin, may occur. As a rule paræsthesiæ are of more uniform intensity and are more constantly present than is pain; but there is no sharp dividing

---

* The explanation of this fact is by no means simple; three factors may be concerned: (1) The weight of the cord itself may tend to slacken the posterior nerve-roots as they pass downward to the intervertebral foramina. (2) The spinal column is longer in the recumbent position than it is in the erect. The increase is due to expansion of the intervertebral discs when freed from their task of transmitting the weight of the body to the pelvis. Nerve-roots are therefore under less tension in the erect position. (3) Dr. A. W. Adson has pointed out to me that there is probably an increase in the fluid pressure in the subarachnoid space during sleep. Thus the headache of intracranial tumour often begins in the early hours of the morning, and a cranial decompression, adequate during the day, may be found tense and bulging after the night. Possibly all three factors are contributory.

line between, for example, a mild burning sensation, and a similar but more intense sensation which is interpreted as painful.

While pain and paræsthesiæ are possibly the only symptoms present, sensory changes may be detected over the area supplied by the affected roots. Diminution in response and over-reaction to stimuli of touch, pain, and temperature may all be present in the skin territory of the affected fibres. The terms 'hyperæsthetic' and 'hyperalgesic' commonly applied to such areas are erroneous, in so far as they describe the condition of only some of the receptors in the area; "within this area there may be defective appreciation of pinprick, but the sensation produced by the latter when the stimulus is effective is abnormally disagreeable. It is better therefore to speak of this as an area of 'over-reaction' rather than 'hyperalgesia'". (Medical Research Council: *Injuries of the Spinal Cord and Cauda Equina.* Special Report Series, No. 88.)

A growth which presses upon the anterior root-fibres discloses its presence by giving rise to disturbances of function of the voluntary muscles which they supply. During the stage of irritation muscular tremors are observed, and occasionally clonic spasms which may be so intense as to be painful. When the nerve-fibres are completely interrupted there occurs a flaccid paralysis of the muscle-fibres which they supply; but before the whole of any one muscle becomes paralysed, the conductivity of all anterior nerve-roots arising from the three adjacent cord segments which supply it must be destroyed. Such a condition is characterized by progressive atrophy of the muscle; at first by the presence of the electrical reaction of degeneration, and later by loss of response to both galvanic and faradic currents; and by the abolition of any reflex which the paralysed muscle may subserve.

As has been emphasized, there may be associated with these features evidence of pressure upon the conducting tracts of the cord, and this has been detailed in a previous section (p. 420). As the tumour grows it gradually affects the more deeply situated bundles until all or nearly all of the conducting systems on the homolateral side of the cord are interrupted. A progressive paralysis of the muscles on the homolateral side of the body innervated by segments of the cord below the point of compression now ensues, and this is of the spastic type. The period which elapses before signs of motor weakness appear is variable; as has been stated, ataxia is often mistaken by the patient for weakness of the affected limb. *Table VII* shows the number of cases in which 'weakness' was an initial symptom (see, however, p. 421).

Table VII.—Number of Cases in which 'Weakness' was an Initial Symptom.

Situation of Tumour	Total	'Weakness,' first Symptom in
Anterior	1	1
Anterolateral	11	1
Posterolateral	38	8
Posterior	7	2

Finally, when the conductivity of one half of the spinal cord is largely interrupted, the patient presents a clinical picture known as the *Brown-Séquard*

syndrome. Reference to the section on CLINICAL PHYSIOLOGY will show that the results of such a unilateral lesion will be the following:—

1. **On the Homolateral Side, in Areas Supplied from Below the Level of the Lesion.**—

a. Spastic paralysis of the muscles, with exaggeration of the reflexes in which they are concerned (see, however, p. 431).

b. Loss of appreciation of the compass test.

c. Astereognosis, and loss of the power of appreciating passive movements and of comparing weights.

d. Loss of appreciation of vibration.

2. **On the Contralateral Side, in Areas Supplied from Below the Level of the Lesion.**—

Loss of appreciation of painful, thermal, and tactile (less compass test) stimuli. On account of the varying obliquity with which these fibres cross the cord, such sensory loss will never extend quite so high as the level supplied by the segment involved. Moreover, the level of tactile loss will be lowest, since fibres conveying this sensation cross the cord more obliquely than those conveying sensations of pain and temperature; and such tactile loss is only partial.

Sometimes the area of skin on the homolateral side which is supplied by the nerve-roots arising at the level of the tumour is found to be completely insensitive to all forms of stimuli. In the thorax this area is in the form of a band. Since the researches of Sherrington have shown that complete sensory loss occurs only after the destruction of all the roots arising from the three contiguous segments which are concerned in the innervation of any one area of skin, such a finding postulates the presence of a tumour of sufficient vertical extent to produce this destruction. In addition to this totally insensitive area a zone of over-reaction, usually bilateral, is commonly present at a level which corresponds to the segment of the cord immediately above that compressed by the growth; this zone is due to irritation of posterior nerve-roots by the upper part of the tumour, and possibly by distended blood-vessels and a cerebrospinal fluid under increased pressure.

I have been unable to correlate the position of the tumour with the degree of loss of each of the types of sensation. Most frequently tactile sensation is less affected than the other forms, and this finding is due to the greater number of paths by which impulses conveying sensations of touch may travel in the cord. Rarely—as in two cases in this series—tactile sensation may be preserved when there is complete analgesia and thermanæsthesia. The deep-pressure sense and that of position of joints are often retained until a late stage of the disease, although in isolated cases the latter may be impaired singly. Selective interference with afferent impulses is more often a feature of intramedullary growths.

If operation is undertaken in the presence of evidence of unilateral compression, it is occasionally found that the sensory loss has been on the same side as the tumour, while the earliest motor palsy has appeared on the contralateral side. This group of symptoms and signs is known as the '*reversed Brown-Séquard syndrome*'. It has been explained on mechanical grounds as

the result of displacement of the cord against the bony wall of the spinal canal on the side opposite to the growth.

As the interruption of the cord progressively involves the contralateral side, spastic paralyses appear on this also, and sensory changes are found on the homolateral side. At this stage examination shows sensory loss which varies somewhat with the relation of the growth to the cord, although in late cases it is relatively easy to map out the upper level of the defect. When the sensory loss is at all profound, sphincteric disturbances are present in from one-third to one-half of the cases (p. 440). As the paralysis deepens, the posture of the limbs, and especially of the lower limbs, assumes one of the two forms to which attention was originally directed by Babinski: 'paralysis in extension' and 'paralysis in flexion'.

Paralysis in Extension.—This occurs when the great corticospinal motor tracts alone are damaged. The increase in tonus affects extensors and flexors equally. It is possible for this type of paralysis to occur in cases of leptomeningioma, although it is more characteristic of hemiplegia and primary lateral sclerosis. But when a tumour is situated on the ventral aspect of the cord at the level of the highest cervical segments, its pressure falls first and most severely upon the pyramidal tracts, here situated on the surface. In this condition the arm is flexed and pronated, the leg extended at the hip and the knee, the foot plantar-flexed and the toes dorsiflexed. The spasticity is increased by efforts at movement, but is diminished during sleep, when the tonic centres in the mid-brain are not stimulated to activity by a constant centripetal stream of external impressions.

Paralysis in Flexion.—This is the usual posture assumed by the limbs of patients suffering from such extramedullary growths. In these cases the pressure affects not only the pyramidal but also the extrapyramidal tracts; the loss of the tonic influence of the latter principally affects the extensor group of muscles, while the flexor group maintains a considerable degree of tone. The hip and knee are flexed, the ankle is dorsiflexed. Extreme activity of the reflexes of defence is the characteristic feature of this type of paralysis; the tendon-jerks subserved by extensor muscles may be greatly diminished or lost (knee-jerk, ankle-jerk), although such a reflex as the hamstring-jerk is increased. The degree of flexion is from time to time increased by involuntary and sometimes painful spasmodic contractions of the flexor muscles.

Occasionally the degree of spasticity is so extreme that the term *hyperspastic* is applied to the paralysis (Mouzon). This may be either in flexion or extension; the rigidity persists during sleep, and spontaneous painful spasms are frequent.*

In the most severe cases of compression of the cord, the paralysed muscles pass through a spastic stage to a final stage of flaccidity. Voluntary movement is impossible, and no skin- or tendon-reflexes can be obtained in the

* A short explanation of these differences in tonus may be germane to the subject. There are two great reflex systems: (1) The extensor, which maintains a steady tonus and is postural in type. This tonus is said to be controlled by a distinct subcortical descending tract which originates in the mid-brain. (2) The flexor, which is a pure spinal reflex and phasic in type. It is unaffected by severance of the cord from the brain, and is 'prepotent'—that is, it may replace the tonic extensor reflex.

extremities. Such a state is generally held to be proof of irrecoverable damage to the nervous tissue of the cord, but in one case in this series the patient recovered some motor power after removal of the tumour. In this case laminectomy was performed eight months after the onset of symptoms, when the patient had complete flaccid palsy of both legs. A growth at the level of the ninth dorsal vertebra had compressed the cord to half its normal size. It was completely removed, and two months after operation muscular power had returned almost entirely.

In the final stages of the disease the patient is, of course, completely bed-ridden. Paralysis and sensory loss are absolute below the level of the growth, and the evacuations are passed involuntarily. Moreover, his condition is intensified by the appearance of trophic disturbances. The insensitive skin is smooth and shiny, and the subcutaneous tissues may be œdematous. Trophic ulcers form, and the most extreme care is required to prevent the occurrence of bed-sores upon such projecting parts as the sacrum and great trochanters. Vasomotor disturbances such as are met with in Raynaud's disease or erythromelalgia may appear. There may be either profuse sweating or anidrosis of the parts; this question will be discussed when the localizing value of sudomotor reflexes is considered. Such patients are very subject to infection of the genito-urinary system, and indeed a common cause of death in untreated cases is severe pyelonephritis, secondary to the cystitis which it is almost impossible to prevent. Intercurrent respiratory infections carry off other patients, whose condition of inanition makes such a complication almost always fatal. Organisms from infected bed-sores may reach the general circulation, and even, by direct extension, the subarachnoid space. Still other sufferers die of exhaustion, worn out by pain and lack of sleep.

XIV. LEPTOMENINGIOMAS IN SPECIAL SITUATIONS.

Cervical Region.—Tumours of the upper part of the cervical region present many interesting features. Large specimens may extend through the foramen magnum into the posterior fossa of the skull, in dangerous proximity to the medulla oblongata and the last four cranial nerves. Thus in a case reported by Frazier and Spiller there was atrophy of one side of the tongue, and after operation the patient died of respiratory failure, doubtless due to paralysis of the respiratory centre in the bulb as a result of post-operative œdema. Respiratory difficulty prior to operation may occur from paralysis of the diaphragm (phrenic nerve) and the accessory muscles of respiration. Sometimes difficulty in swallowing and dysarthria are present. From implication of the posterior root of the second cervical nerve severe headache may be felt throughout the distribution of the great occipital nerve, and pressure on the upper cervical anterior roots may lead to atrophy of the nuchal muscles on one side. A full report upon a patient with such a tumour who came under my observation is presented on p. 462. It may be mentioned here that this patient had vomiting which was not associated with nausea; however, there was no papillœdema.

When the level of the tumour is such as to cause spastic paralysis of the arms, an interesting condition known to the ancients as *pandiculation* may be

observed. Here the act of yawning is accompanied by involuntary movements of the arms and fingers similar to the voluntary movements often performed with this act, termed 'stretching'. According to Purves-Stewart, "these movements are due to uncontrolled activity of the striato-spinal system. In other words, they are released postural reactions in muscles deprived of voluntary control, and the more severe the lesion of the pyramidal tract, the more marked is the pandiculation". Pandiculation was an interesting feature of the case mentioned in the preceding paragraph. When the growth is in the region of the lowest four cervical segments, there may be flaccid palsy of one arm. Usually the sequence of paralysis is: (1) Homolateral arm; (2) Homolateral leg; (3) Contralateral leg; (4) Contralateral arm—an order which affords evidence of grouping of the fibres in the pyramidal tract according to their distribution. In a few cases the contralateral side is first affected, as a result of pressure of the cord on the opposite bony wall.

As one manifestation of disturbed sympathetic innervation, tumours of the cervical cord may give rise to differences in the size of the pupils. In common with other associated phenomena, this is due to pressure upon visceral efferent pathways in the lateral columns of the cord; sympathetic fibres do not leave the cord until these tracts reach the eighth cervical segment.

Occasionally growths in this region give rise to false localizing signs. Thus at first they may cause sensory and motor symptoms referable to the lower extremities. These are the result of pressure upon both afferent and efferent conducting tracts, and it would appear that the fibres serving the extremities, and even parts of the extremities, are gathered into groups in the lateral columns. If the incidence of the pressure be such as to involve the bundles for the lower extremities early in the disease, these 'false signs' appear, and only careful neurological and other examinations will prevent the performance of laminectomy at a wrong level.

Dorsal Region.—When the growth is situated in the middle part of the dorsal portion of the cord, signs and symptoms may appear which are referable to segments above its level. Thus there may occur pain and paræsthesiæ along the internal aspect of the arm and in the fingers, which may precede or accompany true root pain. Vasomotor disturbances and a sensation of weakness may also be present in the same area. These 'false' localizing data have been variously explained as being the result of disturbances in the sympathetic system (p. 422), or as being due to irritation of the cord at this higher level consequent upon an increase in the pressure of the cerebrospinal fluid above the growth. Again, pain may be complained of in areas distal to the distribution of the segment of the cord involved. For example, a patient having a tumour in the mid-dorsal region may suffer from pain in the legs. Such pain is felt in a zone which does not usually correspond to the distribution of any one nerve, and may appear on the opposite side of the body after a unilateral course of months. It is increased by exercise and occasionally started by jerky movements of the spine. At the same time there may occur sudden momentary palsies of the legs as a result of which the patient may fall; similar momentary ataxias of the lower

extremity are also found.* Sometimes vasomotor disturbances of the lower limbs manifest themselves as a varying amount of œdema about the feet and ankles.

It is difficult to offer a satisfactory physiological explanation for these pains. The theory that they are due to pressure of the cerebrospinal fluid upon the posterior columns of the cord does not completely explain all the facts. This is certain, that their distribution places their origin in the cord itself and not in any of its nerve-roots. They are probably due to the pressure of the tumour upon the ascending tracts in the lateral columns of the cord, and like those occurring in cases of cervical growth offer evidence for the grouping of these fibres according to their ultimate connections. Their importance lies in the fact that if their true character is not recognized, the cord may be explored at a wrong level.

Conus and Cauda Equina.—Several distinctive features characterize the lowest part of the spinal canal and its contents :—

1. The lumbar and sacral portions of the bony canal are relatively roomy.

2. The spinal cord ends at the lower border of the first lumbar vertebra.

3. The lumbar, sacral, and coccygeal segments are very close together at the lower end of the cord. Thus they are crowded into that portion of it lying under the tenth, eleventh, and twelfth dorsal spines.

4. Below the level of the lower border of the first lumbar vertebra the bony canal is occupied by the lumbar, sacral, and coccygeal nerve-roots.

From these features two generalizations may be made with regard to tumours of this region :—

1. A relatively small tumour at the lower end of the cord may affect several cord segments, and therefore a wide peripheral area. Moreover, it may implicate several nerve-roots, as well as the cord itself.

2. A tumour of the cauda equina may grow to a very large size ('giant tumour') without definitely announcing its presence. The roominess of the canal and the mobility of the nerve-roots permit the growth to expand widely in all directions without causing symptoms of pressure upon the structures among which it is growing. Further, in this situation the clinical features will be referable to nerve-roots, and evidence of interruption of conducting tracts will be lacking. Rarely is it possible to foretell the level of such a tumour accurately, since widely separate areas are supplied by nerve-roots which here descend close to one another for considerable distances (p. 452). In comparison with other types of growth found in this situation the lepto-meningiomas tend to give a relatively clear-cut picture (moderate size, encapsulation), although in many cases the history is a long one (slowness of growth).

The characteristic syndrome presented by a tumour of the cauda equina includes pain, atrophic paralysis of the legs, perianal and other anæsthesiæ, and disturbances of the sphincter muscles of the bladder and rectum.

---

* These findings are more common in cases where the cord is compressed by an extra-dural growth. They are probably due to sudden changes in the relation of the tumour to the cord.

Pain.—This is the first and may be for long the only symptom. It may be constant from the beginning or may become so only after one or more paroxysmal attacks. In character it is apt to be of the dragging, pulling, or burning type, and it is worst in the recumbent position. It is aggravated by jolting or twisting movements of the spine, and particularly by internal rotation and adduction of the hip-joint, a manœuvre which stretches the affected roots. Oftentimes it begins as a diffuse vaguely localized 'lumbago', or over one or both trochanteric regions. Later it may radiate over the distribution of one of the main nerves of the limb, for example as 'sciatica', which may be bilateral. Occasionally there are paræsthesiæ such as numbness in the feet. Pain and tenderness over a particular vertebra may indicate the segment from which an affected root arises.

Atrophic Paralyses.—All degrees of atrophic paralyses up to complete palsy may be encountered. Usually by the time these patients come to operation muscles of both limbs are affected, although perhaps unequally. In the early stages fibrillary twitchings may be observed, and in some of these muscles atrophy may not be demonstrable, although definite loss of power and loss of tonus are present. Occasionally the paralyses are selective: thus bilateral footdrop is a common finding. When the growth is of sufficient vertical extent to reach the lower end of the cord itself, some of the muscles may be spastic while others are flaccid. The latter show the usual changes in their response to faradic and galvanic currents.

Anæsthesia.—In all the cases in this series sensory changes were present. The degree of loss varies from slight blunting of appreciation to total anæsthesia for all forms of sensation. If the changes are slight, the areas affected are ill-defined and difficult to delimit accurately; on the other hand, complete interruption of one nerve-root gives rise to an area which is sharply marked off from surrounding normal areas, since these may derive their supply from roots which take their origin some segments away from the affected root. Occasionally, as in the case of growths at a higher level, the loss of sensation may be dissociated; thus in one patient, where the tumour was at the lower border of the first lumbar vertebra, touch was felt over the whole of both limbs, although below the knees there was a loss of response to painful and thermal stimuli which was almost complete in the feet; and often the deep pressure sense alone is well preserved. A frequent finding is the so-called saddle anæsthesia', which involves the penis, scrotum, and perianal regions, and is due to involvement of the third, fourth, and fifth sacral roots. Occasionally the destructive process seems to pick out only a few fibres of a root, as in a case which presented a small oval area of total anæsthesia over Hunter's canal on one side, in the territory of the third lumbar root. While in many cases the sensory changes are roughly proportionate to the degree of motor loss, the history of their appearance and progress does not aid the determination of the point of origin of the tumour, for the patient is often unaware that any sensory loss is present.

Reflexes.—As in other types of lower motor neurone palsy, the tendon-jerks are diminished or absent. When the growth presses upon the epiconus there may be evidence of interference with the pyramidal tracts, as in a case reported by Neuhof in which absent tendon-jerks were associated with bilateral

upward movement of the great toe on stimulating the sole of the foot. When the anal and bulbocavernosus reflexes are preserved the epiconus is obviously undamaged.

Disturbances of the Sphincters.—These are dealt with below.

XV. DISTURBANCES OF VESICAL, SEXUAL, AND RECTAL FUNCTIONS.

VESICAL FUNCTIONS.

Like other organs whose walls are composed of smooth muscle, the bladder receives nerves from both sympathetic and autonomic systems. All these nerves reach it from the hypogastric plexus. Those derived from the sympathetic system leave the spinal cord by way of the anterior roots of the third, fourth, and fifth lumbar nerves and pass to the inferior mesenteric ganglion, where the majority are interrupted and their impulses transferred to new neurones which pass without further interruption through the hypogastric plexus to the bladder wall. The autonomic fibres arise from the second and third sacral segments, and on each side unite to form the *pelvic nerve*. This passes to the hypogastric plexus, where the fibres have their cell stations; thence the new neurones pass to the bladder wall. There are numerous ganglia upon the ramifications of these nerves in the musculature of the viscus; their presence no doubt accounts for its capacity of contraction even after its connections with the central nervous system have been severed completely. The compressor urethræ or external sphincter is composed of striated muscle, and is innervated by the pudic nerve, derived from the second, third, and fourth sacral segments. The arrangement and distribution of these nerves is shown in *Fig.* 273, and what is known of their functions may be tabulated as follows:—

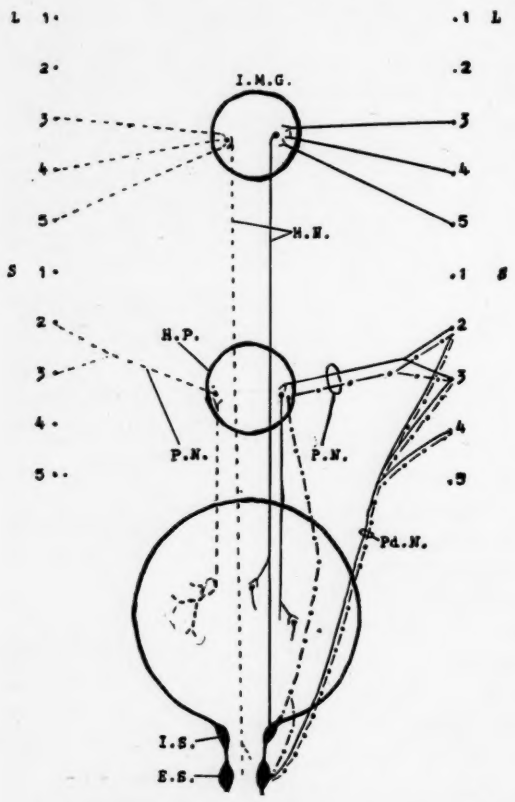


FIG. 273.—Diagrammatic representation of the innervation of the bladder and its sphincters, constructed from a paper by F. J. F. Barrington. (Cf. *Table VIII.*) L, Lumbar segments; S, Sacral segments; I.M.G., Inferior mesenteric ganglion; H.P., Hypogastric plexus; H.N., Hypogastric nerve; P.N., Pelvic nerve; Pd.N., Pudic nerve; I.S., Internal sphincter; E.S., External sphincter.

Efferent fibres: Motor——— Inhibitory—·—·—
Afferent fibres - - - - -

Table VIII.—Impulses Carried by Nerves of the Bladder.

Nerve	Efferent		Afferent
	Excitor	Inhibitory	
Hypogastric ..	Bladder and urethra	—	Posterior urethra
Pelvic ..	Bladder	Both sphincters	Bladder
Pudic ..	Compressor urethræ	(Compressor urethræ)	—

According to Barrington, upon whose work the following description is based, reflex micturition depends upon five reflexes :—

"1. Distention of the bladder leads to a powerful sustained contraction of the bladder. Both afferent and efferent paths of this reflex are in the pelvic nerves. This reflex is abolished by dividing the spinal cord. . . .

"2. Running liquid through the urethra leads to a powerful sustained contraction of the bladder. The efferent path of this reflex is in the pelvic nerves, the afferent usually in the pudic nerves. This reflex is destroyed by transection of the spinal cord. . . .

"3. Distention of the posterior urethra leads to feeble, transitory contractions of the bladder. Both paths of the reflex are in the hypogastric nerves. The reflex is not destroyed by division of the spinal cord in the lower thoracic region.

"4. Running liquid through the urethra leads to relaxation of the urethra. Both paths of this reflex as it was observed were in the pudic nerves . . . the method of observation does not exclude the possibility of the other two pairs of nerves taking part in the efferent side of the reflex. The reflex is not destroyed by division of the cord in the lower thoracic region. . . .

"5. Contraction of the bladder provoked by distending it leads to relaxation of the urethra. The afferent path of this reflex is in the pelvic nerves, and the efferent in the pudic nerves. The reflex . . . is not abolished by dividing the cord in the posterior thoracic region."

These observations were made upon various mammals, and it is uncertain how far the results can be applied to the act of micturition in man. Nevertheless, as will be shown, the various disturbances of control found in compression of the cord can be explained on the basis of Barrington's five reflexes.

The state of the sphincter muscles is under cortical control ;* and this control is exercised according to information reaching the brain relative to the degree of distention of the bladder. Such impulses enter the spinal cord by way of the pelvic nerves, and are said to reach the higher centres through a series of short relays within its lateral columns. It is commonly found that sensory changes are already profound when the first derangement of the

* One cortical micturition centre, which controls the voluntary sphincter muscle and the bulbocavernosus muscle, is situated in the precentral gyrus, between the hip and shoulder motor centres. A second centre, controlling and inhibiting the internal bladder sphincter, is situated on the mesial aspect of each cerebral hemisphere, in the paracentral lobule, close the cortical centre for the toes. (Purves-Stewart.)

functions of the bladder appears, and this is attributed to the continued passage of sensations from the bladder along alternative short paths even after the main sensory tracts have been grossly affected.

The occurrence of vesical symptoms in the series under review will now be tabulated from two different standpoints: that of the level of the tumour, and that of the relation of the tumour to the circumference of the cord.

Table IX.—Occurrence of Vesical Symptoms at Various Levels of the Spinal Cord.

Of 8 *cervical tumours*:—	
Condition of bladder not stated	1
Of remaining 7:—	
No disturbance	3 (43 per cent)
Disturbance an initial symptom	2
Disturbance a late symptom	2
Of 38 *dorsal tumours*:—	
Condition of bladder not stated	4
Urinary difficulty present, time of onset not stated	1
Of remaining 33:—	
No disturbance	6 (18 per cent)
Disturbance an initial symptom	1
Average duration of all dorsal tumours	32 months
Average interval before vesical symptoms appeared viz., after 72 per cent of the course of the disease had passed.	23 months
Of 10 *lumbosacral tumours*:—	
Condition of bladder not stated	0
Urinary difficulty present, time of onset not stated	1
Of remaining 9:—	
No disturbance	2 (22 per cent)
Disturbance an initial symptom	1
Average duration of all lumbosacral tumours	24 months
Average interval before vesical symptoms appeared viz., after 79 per cent of the course of the disease had passed.	19 months
Of 4 *tumours of conus and cauda*:—	
Condition of bladder not stated	0
Urinary difficulty present, time of onset not stated	0
Of these 4:—	
No disturbance	0
Disturbance an initial symptom	0
Average duration of tumours of conus and cauda	49 months
Average interval before vesical symptoms appeared viz., after 90 per cent of the course of the disease had passed.	44 months

Table X.—Occurrence of Vesical Symptoms in the Various Relationships of the Growth to the Spinal Cord.

Of 1 *anterior tumour*:—	
Duration 66 months, disturbance an initial symptom	
Of 11 *anterolateral tumours*:—	
Condition of bladder not stated	2
Urinary difficulty present, time of onset not stated	1
Of remaining 8:—	
No disturbance	1 (12 per cent)
Disturbance an initial symptom	1
Average duration of all anterolateral tumours	31 months
Average interval before vesical symptoms appeared viz., after 90 per cent of the course of the disease had passed.	27 months
Of 38 *posterolateral tumours*:—	
Condition of bladder not stated	2
Urinary difficulty present, time of onset not stated	1

Of remaining 35 :—	
No disturbance	8 (23 per cent)
Disturbance an initial symptom	0
Average duration of all posterolateral tumours	31 months
Average interval before vesical symptoms appeared ..	18 months
viz., after 60 per cent of the course of the disease had passed.	
Of 7 posterior tumours :—	
Condition of bladder not stated	1
Urinary difficulty present, time of onset not stated	0
Of remaining 6 :—	
No disturbance	2 (33 per cent)
Disturbance an initial symptom	2
Average duration of all posterior tumours	12 months
Average interval before vesical symptoms appeared ..	11 months
viz., after 92 per cent of the course of the disease had passed.	

Consideration of these figures shows that there is little relation between either the level of the tumour or its position relative to the cord and the occurrence of vesical symptoms. An explanation of the latter may now be offered.

1. **Lesions above the Level of the Second Lumbar Segment.**—Urgency of micturition is the first complaint. In such cases all five reflexes are still operating, but some of the afferent impulses from the bladder to the brain have been interrupted. When the viscus reaches a certain stage of distention the whole sequence of reflexes is initiated. This does not result from a primary forcing of the sphincters, since contraction of the musculature of the bladder is evoked by a lower pressure than that necessary to do so ; it is due to their reflex relaxation, unchecked by an ill-informed brain. When the urine has entered the posterior urethra the operation of the second and third reflexes makes the demand imperious.

As the fibres conveying bladder sensation become more involved, the ease with which this reflex escapes cerebral control increases. The patient passes through a stage of nocturnal incontinence (when the weakened cerebral control cannot be reinforced by conscious effort) to the stage of periodic reflex micturition of which he is aware, and finally to the stage of periodic reflex micturition of which he is totally unaware. It is to be noted that at no time is there a stage of retention with 'overflow incontinence' such as is present immediately after acute transverse lesions of the cord.

Periodic reflex micturition cannot be due to a return to the normal combination of bladder contraction and sphincter relaxation, for such patients have always a variable amount of residual urine in their bladders. Moreover, the first two reflexes described are no longer operative. But since the tonic influence of the pudic nerves upon the external sphincter is also absent, a certain degree of intravesical pressure will cause urine to enter the urethra ; the remaining three reflexes then come into operation. The clinical features are therefore due to a relaxation of the sphincter mechanism. In addition the capacity of spontaneous contractility possessed by the musculature of the bladder may be sufficient to set in action the whole train of reflexes.

In the presence of a ventral tumour incontinence may occur only when the patient is recumbent : there is full control in the erect position. Probably the explanation of this feature is similar to that of the fact that root pain is worst at night (p. 430).

2. **Lesions of the Second, Third, Fourth, and Fifth Lumbar Segments.**—The sequence of symptoms is the same as that detailed in the preceding paragraph, save that the relatively unimportant third reflex is not present to augment the urgency and force of the reflex act.

3. **Lesions of the Second, Third, and Fourth Sacral Segments.**—In these lesions bladder symptoms appear relatively early, since the pressure is exerted upon both afferent and efferent fibres to the bladder where these are concentrated in the roots and cord. They are at first irritative, and since the pelvic nerves convey the majority of important stimuli to and from the bladder, there results a period of hypersensitivity of that organ, characterized by a frequent desire to micturate. The act may be painful if the bladder has to overcome the resistance of an external sphincter thrown into spasm as a result of pressure upon the nerve-roots supplying it. In the later stages there is incontinence, and this is of a different type from that previously described. Both the detrusor muscle and the main sphincter mechanism are paralysed, and the bladder becomes a sac devoid of sensation which is passively distended with urine. At intervals the intravesical pressure rises sufficiently high to force the internal sphincter, and urine escapes. The escape does not cease when the pressure falls below that level, for the third reflex is still intact, and the feeble contractions evoked through the hypogastric nerve may succeed in expelling an additional amount.

4. **Lesions of the Cauda Equina.**—In cases where the tumour implicates the cauda equina, disturbances of function of the bladder are by no means constant, and if present are a late feature. This is no doubt due to the escape of the whole or part of the fibres passing to the viscus. The clinical features are similar to those discussed in (3) above.

Cystoscopic Appearances.—The wall of the bladder is flabby, and trabeculation, if present, is slight. There is often marked loss of expulsive force. The condition of the sphincter varies with the level of the lesion, and may be deduced from the foregoing considerations. It is a noteworthy fact, and one which I have not seen emphasized elsewhere, that although somatic signs and symptoms may be referable almost wholly to interference with the conductivity of one-half of the cord, nevertheless the musculature of the bladder is affected as a whole. I have never observed unilateral atony in a case of cord bladder,

SEXUAL FUNCTIONS.

The act of erection is the result of efferent impulses which reach the penis through the pelvic nerves. It may be brought about in a reflex manner as a result of sensory impulses from the genitalia, which reach the cord by way of the pudic nerves; and it may also be accomplished through the action of cortical impulses upon the cells in the cord from which the efferent fibres of the pelvic nerves arise. Therefore lesions of the cord above the level of the second sacral segment diminish or abolish cortical control, and conscious erotic sensations (pudic nerves). Tumours situated at the point of origin of the pelvic nerves, and tumours implicating the second and third sacral roots, may diminish and even destroy the power of erection. Occasionally, as in a case in the present series which has been discussed by Parker, the power of

erection is retained while that of ejaculation is lost. This observer agrees with Spiller that such a finding is best explained by supposing that the fibres which govern the act of erection leave the cord at a higher level than those which control the ejaculatory muscles. The origin of the former is said to be chiefly in the second sacral segment. When the growth involves both segments, or the roots arising from them, neither erection nor ejaculation occurs.

RECTAL FUNCTIONS.

The rectum possesses two sphincters—an internal of plain and an external of striped muscle. The tonus of the former is maintained by the pelvic nerves; the latter is supplied by the pudic nerves. Of the two the external is by far the more efficacious, although when the motions are hard and formed the tone of the internal sphincter may be sufficient to retain them, even when the external sphincter is paralysed. When the tumour is above the level of the second sacral segment, the first disturbance of defæcation to appear is persistent obstinate constipation. Normally the entrance of fæces into the rectum gives rise to afferent impulses which produce the desire to defæcate. If the occasion be suitable, the tone of the external sphincter is relaxed by conscious cortical control. Extramedullary pressure gradually cuts off the external muscle from cerebral impulses; it remains tonically contracted, and constipation is the result. Later the tonic influences conveyed by the subcortical extrapyramidal tracts are gradually interrupted, and the external sphincter becomes more and more toneless. At first urgency and later incontinence occurs when the motions are fluid, as after the exhibition of purgatives. In the final stages even the slight tonus possessed by the internal sphincter may be lost—a condition for which there is at the present time no satisfactory explanation. In these circumstances, and provided the fæces are of a sufficiently fluid consistency, the rectum empties whenever fæces enter it. If the lesion is such that the muscles of the abdominal wall are paralysed, distressing flatulent distention of the bowel may appear, from the absence of their accessory aid in the act of defæcation. When the growth implicates the second, third, and fourth sacral segments, or the roots arising from these, the external sphincter may be paralysed at any stage, early or late, and incontinence results.

XVI. ACCESSORY AIDS TO DIAGNOSIS.

While a careful history and a complete neurological examination must always provide the greater part of the information upon which a diagnosis of extramedullary tumour is based, valuable confirmatory evidence may be obtained from two additional sources: (1) *An examination of the physical and chemical properties of the cerebrospinal fluid.* (2) *Radiography of the spinal column after air or lipiodol has been introduced into the subarachnoid space.*

1. EXAMINATION OF THE CEREBROSPINAL FLUID.

Properties of the Cerebrospinal Fluid in Health.—

PHYSICAL PROPERTIES.—If a hollow needle (the most suitable bore is 1·50 mm.) is introduced into the subarachnoid space and connected to a

three-way stopcock, the pressure of the cerebrospinal fluid may be measured by fitting to the vertical limb of the stopcock either a straight tube graduated in centimetres from its lower end—when the pressure is measured in terms of centimetres of cerebrospinal fluid—or a mercury manometer, when it is expressed in terms of millimetres of mercury. The former method is that usually employed (*Fig.* 274). When it is used, the range of pressure, taken with the subject lying on his side at rest and with head and spine in the same horizontal plane, is from 80 to 190 mm. Waves of increased pressure synchronous with the arterial pulse (3 to 5 mm.) and with expiration (5 to 10 mm.) can thus be demonstrated, and for test purposes the pressures may be raised: (1) By the patient's coughing, crying, or sneezing. Forced expiration momentarily checks the return of blood to the heart, and so reduces the intracranial space available for the cerebrospinal fluid. (2) By obstructing the venous return from the head by digital compression of the internal jugular veins. The second of these methods is known as Queckenstedt's test.

FIG. 274.—Cerebrospinal-fluid manometer, as made to the author's specification by Messrs. Down Bros. The stopcock is connected to a spinal puncture needle. By means of the tap, fluid may be taken for examination, or allowed to enter the manometer. The bore of the tube is 2 mm., and it is graduated in centimetres *from the level of the needle.* For high pressures the second piece is first fitted to the stopcock, and the piece at present in position is then joined to its upper end.

Queckenstedt's Test.—Compression of the veins is best carried out by an assistant, while the operator observes the manometer. The rise and fall in subarachnoid pressure may be shown graphically, as in *Fig.* 275. The pressure may be lowered: (1) By the patient's taking a deep inspiration. As a result of expansion of the chest, blood is sucked from the cranial cavity into the heart. (2) By the withdrawal of fluid through the stopcock.

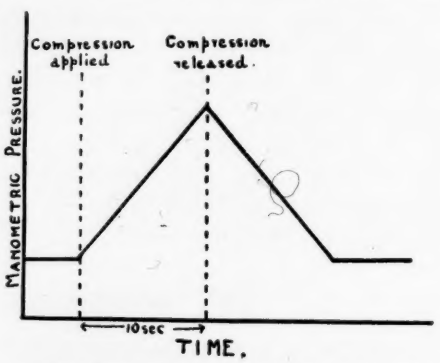


FIG. 275.—Graphical representation of type of response to Queckenstedt's test where there is no block. Both rise and fall are sharp, the former begins immediately pressure is applied, and neither occurs by stages. At the conclusion of the fall the pressure has regained its original level.

Normally there is free communication between all parts of the subarachnoid space, so that if manometers are connected to it both in the lumbar region and at the cisterna magna, provided that the cranial and caudal needles are in the same horizontal plane the pressures are identical, with the exception that the rise due to systole of the heart is more evident in the cranial manometer (on account of pulsation transmitted from the neighbouring large intracranial vessels). In health the fluid is clear, colourless, and sparkling. Its specific gravity is about 1·006, and it does not coagulate on standing.

CHEMICAL PROPERTIES.—Only those properties variations from which are of use in the diagnosis of leptomeningiomas will be considered here.

Protein Content.—This varies from 5 to 15 mgrm. per 100 c.c. in fluid obtained from the ventricles to 30 to 40 mgrm. per 100 c.c. in fluid obtained from the lumbar sac. A figure higher than 50 mgrm. per 100 c.c. in fluid from the latter is definitely abnormal.

Fibrinogen and Thrombokinase.—These are absent.

CYTOLOGY.—In the sediment obtained after spinning healthy cerebrospinal fluid which is free from blood, but two types of cells are commonly seen under the microscope: (1) Small mononuclear lymphocytes form the greater number of cells; (2) Occasionally a large mononuclear cell is observed. This is either hæmatogenous in origin, or it is a shed arachnoid cell (p. 402). Normally the total number of cells present in 1 c.mm. of fluid does not exceed *seven to twelve.*

Changes in the Cerebrospinal Fluid in Cases of Leptomeningioma of the Cord.—

PHYSICAL CHANGES.—When spinal puncture is performed below the level of the tumour the cerebrospinal fluid is usually found to be under diminished pressure, although normal pressures are by no means uncommon, and occasionally increased pressures may be encountered. The usual explanation given for this diminution of pressure below a block is that this portion of the subarachnoid space is more or less completely cut off from the source of the fluid, so that there results a decrease in the quantity which it contains. Although hitherto it has been generally accepted, this theory does not entirely explain the loss of pressure, for it has been proved that sacs of the subarachnoid space isolated and emptied of their content fill again with fluid within twelve hours. It is probable, however, that this liquid is not true cerebrospinal fluid, but a transudate from the vessels of the cord which reaches the subarachnoid space from the perivascular lymph spaces. Thus there are sources of fluid other than the choroid plexuses, and since Elman has recently shown that but little absorption occurs around the issuing nerve-roots, the true explanation must be regarded as undetermined. Increased pressure below a block may be due to a valvular action of the growth. The circulation of the cerebrospinal fluid is constantly downward on the posterior aspect of the cord and upward on its anterior aspect. An extramedullary tumour may so fit its surroundings as to permit the downward while preventing the upward flow; exudation of serum from the distended spinal veins may also contribute to the increase.

The Demonstration of Spinal Block.—This is one of the most important confirmatory tests available in the diagnosis of tumour of the cord; it is of greater positive than negative value, and even when positive gives no clue to the level of the growth. It may be carried out in a variety of ways:—

1. By performing lumbar puncture in the usual manner. If there is a block in the space above the level of the interval between the third and fourth lumbar vertebræ, changes in the initial pressure of the fluid may be demonstrable with the manometer. Moreover, there may be an altered, lessened, or absent response to the methods of raising the general pressure in the space. Stookey has described five types of altered response, and these

are illustrated graphically in *Figs.* 276 to 280. The first three are conclusive evidence that a block is present, the last two inconclusive unless supported by clinical evidence of compression of the cord.

2. By the combined cistern and lumbar puncture of Ayer. In carrying out this test needles connected to manometers are introduced into the cisterna magna and the lumbar portion of the sac, the patient being prone on his side;

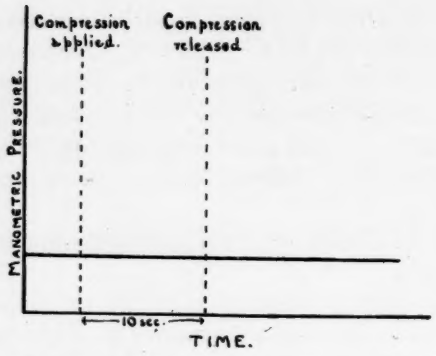


FIG. 276.—Absolute block. No response to jugular pressure.

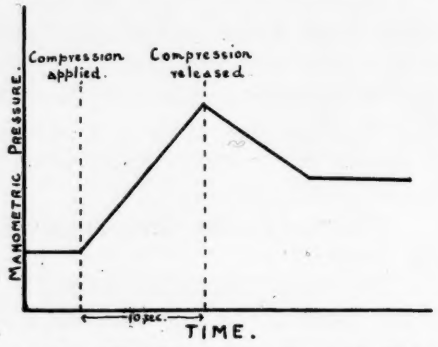


FIG. 277.—Sharp rise. Slow and slight fall. Pressure constant at new and higher level.

care is taken that the two needles are in the same horizontal plane. Pressure readings are noted as previously described, and a record is made of the response in each manometer to the heart's beat and expiration, to Queckenstedt's test, and to other means of raising the pressure of the fluid. About 5 c.c. of fluid are then withdrawn from the lumbar region; normally this causes a fall of 30·00 to 40·00 mm. in each manometer. In the presence of

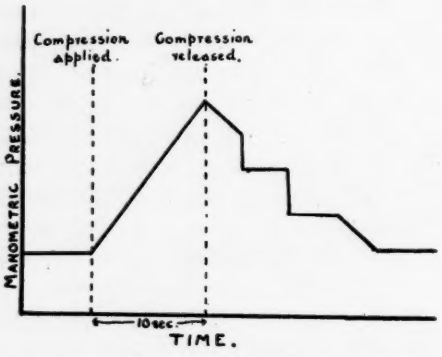


FIG. 278.—Sharp rise. Fall by stages to old level.

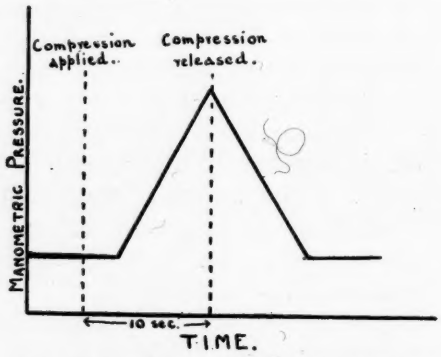


FIG. 279.—Delayed but sharp rise. Sharp fall to old level.

block the manometer connected to the cistern either does not show this decrease or it shows a smaller decrease, the appearance of which may be delayed. The observations on the cardiac and respiratory variations are then repeated; in cases of block they are but little affected in the cistern manometer, while in the lumbar manometer they may be even abolished. By a further application of this test the length of canal within which the block

must lie may be reduced. Thus the two needles may be approximated one to the other by performing punctures at lower and higher levels respectively. The cranial needle may puncture safely in turn the cervical intervertebral spaces down to that between the sixth and seventh vertebræ, while in the Mayo Clinic the caudal needle has been moved as high as the space between the seventh and eighth dorsal vertebræ. If both needles are shifted to the same side of the block in this way, the manometric readings become the same. If the reading in the cranial manometer becomes equal to that in the caudal, the level of obstruction must lie immediately above the last point of insertion of the former; while if the caudal manometer approximates to the cranial, the block must be immediately below the ultimate position of the caudal needle. (*Fig.* 281.)

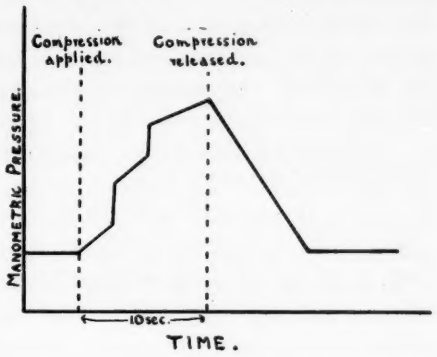


FIG. 280.—Rise by stages. Sharp fall to old level.

3. When the tumour involves the cauda equina, lumbar puncture frequently results in a 'dry tap'—that is, no fluid can be obtained (since the subarachnoid space is filled with tumour). Any block which exists below this level may be demonstrated in one of two ways:—

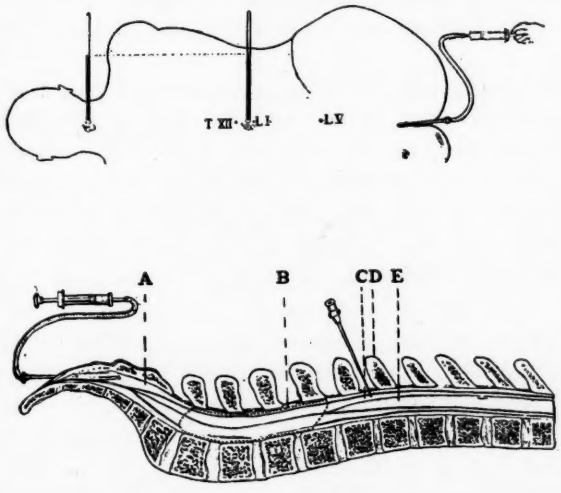


FIG. 281.—The upper figure represents the position of the two manometers in the double puncture of Ayer, and also the method of introducing fluid through the sacral hiatus. The lower figure shows how fluid in the epidural space affects a manometer connected to a spinal-puncture needle inserted between the twelfth dorsal and first lumbar vertebræ. **A**, Epidural space; **B**, Dotted outline of tumour; **C**, Subarachnoid space; **D**, Spine of twelfth dorsal vertebra; **E**, Spinal cord. (*From a paper by Cushing and Ayer.*)

a. A test similar to that described in (2) may be performed, one needle being inserted between the twelfth dorsal and the first lumbar vertebræ, the other between the fourth and fifth lumbar vertebræ.

b. When the tumour lies below the latter level, the former needle alone is used. From 50·00 to 70·00 c.c. of normal saline solution are introduced into the epidural space through the sacral hiatus. Normally this will cause a rise of pressure in the lumbar manometer, for the increase in the content of the bony canal is transmitted to the subarachnoid space through the dura. If the sacral canal contains a tumour, the increase, if present at all, is but slight, and it may be impossible to inject the full quantity of fluid.

(To introduce fluid into the epidural space, the apex and diverging sides of the sacral hiatus must first be identified. The needle is inserted into the sacral hiatus in a perpendicular direction until it is felt to have pierced the ligamentous roof of the opening. It is then brought into the plane of the sacral canal, and pushed onward for five to six centimetres. Before beginning the injection the piston of the syringe should be withdrawn, to ensure that the point of the needle is not resting in a vein.)

CHEMICAL CHANGES.—Chemical changes in that portion of the cerebro spinal fluid below a tumour seem to owe their existence to two factors: the block in the circulation of the fluid, and the compression of the cord. It must be understood, however, that compression of the cord and stasis of the fluid may be present without demonstrable chemical abnormality in the fluid below the block, so that chemical tests have a greater positive than negative value.

The first alteration which may be observed is an increase in the protein content of the fluid. This may be demonstrated by one of the following tests, after care has been taken that the fluid is not contaminated with blood.

1. *The Nonne or Nonne-Apelt Test.*—To 1·00 c.c. of cerebrospinal fluid in a small test-tube add 1·00 c.c. of a saturated solution of ammonium sulphate, mix, and allow to stand for three minutes. At the end of that time compare with a similar control tube containing cerebrospinal fluid alone. A positive reaction is indicated by turbidity or even precipitation in the first tube.

2. *The Pandy Test.*—This, the better of the two tests, is performed as follows. Place 1·00 c.c. of a saturated solution of carbolic acid in distilled water in a small test-tube, and add one drop of cerebrospinal fluid. A positive reaction is indicated by the formation of a faint white cloud where the increase is small, or actual precipitation where a large amount of protein is present. The presence of increased protein in the cerebrospinal fluid, with no increase in the cell-count—the Nonne syndrome—is strong evidence of the presence of a spinal-cord tumour, especially if *block* can also be demonstrated.

Cerebrospinal fluid obtained from the subarachnoid space below a block may show a *yellowish tinge*. The pigment is of hæmatogenous origin, and is present either as the result of transudation from the engorged veins, or from the breaking down of small areas of hæmorrhage which have occurred in vascular tumours, the hæmoglobin being transformed into bilirubin. The second source is rarely contributory in cases of block caused by the type of tumour under discussion. In 1903 Froin described a condition of the cerebrospinal fluid occasionally found below a block, which includes *increased protein content, presence of a yellowish colour*, and *capacity of spontaneous coagulation —'xanthochromie et de coagulation massive'*—combined with a *normal or but slightly increased cell-count*. The association of these features is characteristic of the isolation of part of the subarachnoid space by a non-inflammatory process. Leschke states the incidence of coagulation in cases of extramedullary tumour as 24 per cent; in cases of tumours of the cauda equina as high as 90 per cent. It is not mentioned in any of the case reports in this series. The complete Froin syndrome occurs in from 20 to 30 per cent of all cases showing a yellow cerebrospinal fluid. Spontaneous coagulation is due

to the presence of large amounts of albumin, fibrinogen, and fibrin ferment. The amount of the first substance may be as much as 2·01 grm. per 100 c.c. (normal about 0·02 grm.). The coagulation may occur almost immediately on withdrawal of the fluid, or not until after a period of some hours.

Recently Cushing and Ayer have drawn attention to the fact that increased protein content without xanthochromia (two cases) and even the complete Froin syndrome (one case) may be present in the cerebrospinal fluid above a tumour. Hammes has noted the latter condition in a case under his observation. The source of the protein and fibrinogen in these cases is more obscure; an inflammatory process is excluded by the absence of increased cell-count. Cushing and Ayer suggest the possibility of transudation from engorged veins below a partial block, and even from the surface of the tumour itself. Mixter has described an unusually high protein content in fluid from the lumbar sac above tumours of the cauda equina.

Finally, as pointed out by Stewart and Riddoch, fluid in an isolated sac of the spinal subarachnoid space is separated from the source of any ferments passed into the space from the choroid plexus and pituitary body.

After this discussion upon the changes in the cerebrospinal fluid, data from the case reports which form the basis of this paper may be presented in tabular form. Of a total of 60 cases, the spinal fluid was partially or completely examined in 40.

Table XI.—Summary of Condition of Cerebrospinal Fluid in 40 Cases.

Pressure :—Not stated	22		
Normal	3		
Reduced	3		
Absent	1		
Increased	2		
Measured	9	Hg 6, 8, 15 mm.	
		C.S.F. 4, 6, 7, 10, 11, 12 cm.	
Block :—Not stated	30		
Absent	2		
Present	5		
Partial	3		
Colour :—Not stated	23		
Normal	7		
Yellow	8		
Gold	1		
Amber	1		
Pandy or Nonne Test :—Not stated	7		
Positive	22	(66·7 per cent)	
Negative	11	(33·3 per cent)	
Number of cells per c.mm. :—Not stated	3		
No pleocytosis	34		
Less than 12			
More than 12	2		
R.B.C.*	1		
Coagulation :—Never noted			
Wassermann or Kolmer :—Not stated	2		
Negative	38		
Colloidal Benzoin Test :—Not helpful, but on the whole flocculation most marked in tubes 8–11.			

* Probably due to contamination with blood.

2. RADIOGRAPHY.

Pneumography.—The method of localizing cerebral tumours by the introduction of air into a lateral ventricle, and subsequent radiography of the head in various positions (as elaborated by Dandy) has been adapted to tumours of the spinal cord. Quantities of air varying from 5·00 to 50·00 c.c. are injected into the subarachnoid space through a lumbar puncture needle after an equivalent quantity of cerebrospinal fluid has been allowed to escape. Radiograms are taken after an hour or two, with the patient in the erect position, in the hope that the bubble of air will be arrested at the level of the tumour where it will be visible in the photographs. The assistance derived from this procedure may be classified under two headings :—

1. *The Upper Limit of the Air-bubble.*—As an aid to the diagnosis of the level of the neoplasm this has proved disappointing ; the upper border of the column of air is often so indistinct as to be of slight value in localization.

2. *The Level of the Pain which Appears after such Injections.*—This is of much more diagnostic value, but decidedly unpleasant for the patient. After a few hours, pain appears at the level of the tumour, and radiates round the body along the nerves arising from the segment involved. This pain is said to be due to the passage of the air past the growth. After it disappears, and in cases where there is no tumour, severe headache may follow. This is doubtless the result of entrance of the air into the ventricles of the brain.

The Use of Lipiodol.—The principle underlying the use of lipiodol is that of the introduction into the subarachnoid space of a substance opaque to the X rays. This substance sinks rapidly when the patient assumes an erect position, is arrested at the level of the tumour, and may be demonstrated there in radiograms. Lipiodol is a colloidal solution of iodine in oil of poppy, in the proportion of 0·54 cgrm. of iodine to 1 c.c. of the oil. It is stated by its inventors to be non-toxic and non-irritating.

The technique of its introduction has been described by Sicard, Paraf, and Laplane, who first elaborated and used it. The oil is usually injected by puncture of the atlanto-occipital ligament. This structure lies some 3 to 5 cm. from the skin ; the dura at the site of puncture is 1½ cm. distant from the medulla oblongata. No cerebrospinal fluid should have been removed from the patient for at least six or eight hours before the injection. This may be made with the patient in the sitting position (Sargent) or lying on his side with head and shoulders slightly raised (Sicard). In either position the head must be well flexed to open up the space between the atlas and the occipital bone. After surgical preparation of the skin a point is selected where a line joining the tips of the mastoid processes crosses the mid-line, and the skin in this area is anæsthetized with a 2 per cent solution of novocain. A spinal-puncture needle is then fitted to a Luer syringe containing about 2·00 c.c. of normal saline solution. The needle is entered immediately to one side of the point described (to avoid the ligamentum nuchæ) and pushed steadily forward and a little upward until it reaches the occipital bone, when the point is depressed, and the needle passed through the atlanto-occipital ligament and dura. If the saline is slowly injected as the needle is introduced, the lumen of the latter is kept patent, and when its point reaches

the subarachnoid space the sudden decrease in resistance to injection as well as the sensation of piercing the membranes indicate to the operator that the puncture has been accomplished. Moreover, the outflow of fluid tends to remove the medulla from any possible injury by the entering needle point. The safety of the procedure has been questioned owing to the proximity of the circular vein round the foramen magnum, but apparently this has never been wounded. When the syringe is disconnected the cerebrospinal fluid either escapes very slowly in drops, or may require to be withdrawn with the syringe; but after verifying the puncture in this way only a few drops should be allowed to escape before completing the injection.

Before the lipiodol is introduced attention must be paid to several technical points: (1) The oil must be transparent; certain specimens tend to lose this essential property. (2) It may be warmed to the temperature of the body by immersing the ampoule in water at 100° F. This decreases its viscosity and thus facilitates its injection. (3) When taken up into the syringe the oil must be quite free from air-bubbles; these tend to make it cling to the meninges. From 1·00 to 1·50 c.c. of lipiodol is then injected slowly, the final traces of the substance being washed from the needle by one or two cubic centimetres of warm saline solution from a second syringe. The needle is withdrawn at once. The whole procedure should be quite painless.

The oil may also be introduced between the fourth and fifth or fifth and sixth cervical vertebræ; or if it is desired to outline the lower border of the tumour, by ordinary lumbar puncture. The technique is essentially the same save that the needle should be allowed to remain in position for one minute before removal to prevent leakage of cerebrospinal fluid and lipiodol into the epidural space.

After the injection into the cistern the patient should be made to sit up, if he is not already in this position, and the upper cervical spines should be percussed firmly to aid the fall of the oil. He should be forbidden to assume the horizontal position for three to four hours. When no block is present the lipiodol reaches the dural cul-de-sac at the level of the second sacral vertebra in five or six minutes. From one to four hours after the injection X-ray pictures of the spine are taken. Exposures should be made with the patient erect, and in the dorsal decubitus with head and shoulders raised. If the oil has been checked in its descent, these exposures are repeated after two or three days, to define any later changes in its level. It is inadvisable to take lateral views with the patient prone on his side, as the normal curve of the lower spine allows the oil to flow back to the region of the fifth lumbar vertebra.

The radiological appearances in cases where a tumour is present vary: (1) In cases where the block is complete the lower edge of the column of lipiodol may be straight. (2) It may conform to the outline of the upper border of the tumour. (3) Some of the lipiodol may outline the tumour while the remainder falls to the sacral cul-de-sac. (4) Sometimes minute shadows of lipiodol may be seen irregularly scattered throughout the length of the subarachnoid space above the block or cul-de-sac. These correspond to the positions of calcareous plaques on the arachnoid membrane. (When the oil is introduced by lumbar puncture the radiograms are, of course, taken with

the head of the patient lowered, since it is the lower border of the growth which is being outlined.)

The inventors state that they have never seen headache, vomiting, or general malaise follow the use of lipiodol. Some hours after the injection there may be shooting pains or uneasiness in the legs, but these are transient. Apparently the iodized oil is well tolerated. It is demonstrable in the sacral cul-de-sac two years after its introduction, and very little absorption takes place in that time.

XVII. DETERMINATION OF THE LEVEL OF THE TUMOUR.

THE RELATION OF CORD SEGMENTS TO BONY LANDMARKS.

The spinal cord ends at the level of the lower border of the first lumbar vertebra, and is therefore considerably shorter than the spinal canal; thus a segment of the cord is not situated opposite its corresponding bony segment. The nerve-roots have a general downward direction toward the intervertebral foramina, and the length of their courses within the spinal canal increases from above downward, as is well shown in *Table XII* (after Soulie).

Table XII.—Intradural Length of the Roots of the Spinal Nerves: Average Length in Millimetres.

Cervical		Thoracic		Lumbar		Sacral		Coccygeal
No.	Mm.	No.	Mm.	No.	Mm.	No.	Mm.	Mm.
1	3	1	29	1	91	1	185	266
2	8	2	35	2	110	2	196	
3	16	3	38	3	132	3	221	
4	18	4	43	4	151	4	239	
5	20	5	45	5	170	5	262	
6	23	6	47					
7	25	7	49					
8	27	8	49					
		9	52					
		10	55					
		11	58					
		12	81					

A given segment of the cord is thus always situated more cranially than the corresponding vertebra. Various rules have been evolved by means of which the spinal canal may be opened at the proper level to expose a given segment. While there are individual variations of relation, which have been studied by Reid, the rule given by the Committee of the Medical Research Council on Injuries of the Nervous System may be quoted in full:—

"1. The intraspinal course increases fairly regularly for the cervical and thoracic nerves. It is about equal to the depth of one vertebra for the upper cervical and of two vertebræ for the lower cervical; of three vertebræ for the upper thoracic and of four vertebræ for the lower thoracic.

"2. The origins of the lumbar nerves (segments) are opposite the tenth and eleventh thoracic spines.

"3. The origins of the sacral nerves (segments) are opposite the twelfth

thoracic spine and the interspinous ligament between it and the first lumbar spine.

"In applying these rules it must be remembered that the spinous processes vary much in length and obliquity, so that in the mid-thoracic region the tip of one spine may reach the level of the middle of the body of the next vertebra but one below it. Moreover, the nominal relation of nerves to vertebræ changes at the eighth cervical nerve—above this level the nerve issues above the vertebra of the same name; below this level the nerve issues below the vertebra of the same name."

The task of the clinician is to determine as accurately as possible the segment of the cord involved. The surgeon then plans a laminectomy suitable for the exposure of this segment. In arriving at the level of the growth information is derived from an analysis of the data given below.

DATA FROM WHICH THE LEVEL OF THE GROWTH IS DETERMINED.

The level of the growth may be determined from the following data:—

1. *Sensory Features*: (*a*) Referable to roots: (i) Somatic; (ii) Splanchnic. (*b*) Referable to conducting paths: (i) Somatic; (ii) Splanchnic.
2. *Motor Paralyses*: (*a*) Upper neurone type; (*b*) Lower neurone type.
3. *The State of the Reflexes*: (*a*) Somatic; (*b*) Splanchnic.

1. Sensory Features.—

a. Sensory Features Referable to Roots.—

i. *Somatic.*—

α. *Pain.*—The site of the original pain, provided this has been constant, and its subsequent radiation, are valuable aids in estimating the level of the growth. According to Bruns, root pain should be referred to the corresponding segment of the cord and not to pressure upon the root as it descends in the spinal canal. It appears to me, however, that cases in which a process of the tumour occupies an intervertebral foramen will form an exception to this rule. When tenderness of one spine is a marked and early feature, it may indicate the posterior root upon which the growth is pressing.

β. *Sensation.*—It has been seen that the destruction of one root does not give rise to sufficient anæsthesia to be of localizing value. When two roots are interrupted the loss is more appreciable, and if three roots suffer, a definite zone of complete loss will be present, and this indicates the level of greatest pressure. For purposes of localization, a study of the area of 'over-reaction' above the tumour level is most helpful. If sensation is tested carefully from above downward, and the level at which *abnormal* sensibility makes its appearance noted, this will represent the level of the upper limit of the lesion of the cord. The limits of anæsthetic areas are best determined where these abut upon areas which derive their nerve-supply from a distant segment of the cord. Thus about the second thoracic interspace the territory of the third and fourth cervical segments meets that of the second dorsal segment, and over the buttock the territory of the first lumbar segment meets that of the third sacral segment.

ii. *Splanchnic.*—Occasionally loss of visceral sensation is an aid to localization, and careful inquiry should be made as to this point. Even in severe

degrees of somatic sensory and motor loss, some visceral sensibility may be retained; this is probably due to the nature of the pathway by which such sensations rise to consciousness (*see* p. 439). In the case of lesions below the ninth and tenth dorsal segments distention of the stomach can always be appreciated. With regard to the bladder, it is important to find out if the patient recognizes the desire to micturate, and if he is conscious of the act. Sometimes the passage of a catheter is felt only when the instrument reaches the trigone of the bladder; and this in spite of extreme pressure upon the lumbar cord. Care must be taken that the patient does not mistake the sensations evoked by the pressure of a distended bladder upon other abdominal viscera for real appreciation of the fullness of the organ. The presence or absence of rectal sensation, and consciousness of the act of defæcation, should also be investigated. In one case in this series the patient was confined during the course of the disease; the pains were slight.

b. Sensory Features Referable to Conducting Paths.—

i. *Somatic.*—The sharpness with which the level of the anæsthesia can be mapped out varies with the size and consistence of the tumour, and with the roominess of the bony canal. A small hard growth which indents the cord deeply leads to the most complete interruption. In determining sensory levels the examination must include tests of all forms of sensation, for, as has been mentioned, dissociated anæsthesia is sometimes present. It must be remembered that in estimating the degree of loss of tactile and thermal sensation, these must be considered as a whole; on account of the regrouping of fibres which takes place in the cord the ability to distinguish between 'protopathic' and 'epicritic' sensibility is abolished. The preliminary determination should be made for pain, since touch loss is often slight and very indefinite in less extensive lesions. Care must be taken that the patient understands that it is sensibility to actual pain which is being investigated, for a needle prick may be appreciated as touch though loss of sensibility to pain is absolute.

When some idea of the level of sensory loss has been reached, the levels for touch, pain, and temperature should each be determined as accurately as possible. As has been pointed out, the level will often be most definite when the insensitive area marches with an area supplied by a distant segment of the cord. In some cases it will be impossible to determine the exact level at which normal sensibility is replaced by abnormal, but the attempt should be made in all by working carefully from normal to definitely abnormal skin; in this way some information may be gained as to the upper limit of the lesion, and this part of the examination assumes its greatest importance when root symptoms have been slight or absent. When the case is not seen until the late stages, and a complete or almost complete interruption of the cord is present, the level of total anæsthesia may be very definite indeed; but it must be emphasized that this level is a guide only to the lowest segment which is completely interrupted, and gives no indication of the vertical extent of the lesion. When the vibratory sense is being tested, mistakes may arise from the vibrations of the fork being transmitted along the bones of the leg from an insensitive to a sensitive area. The tuning-fork test is more reliable when applied to the abdominal wall; and it often proves of value when applied to the spinous processes of the vertebræ, when it may be found that

there is a marked difference of appreciation between two adjacent vertebræ. (The vertebra at which vibratory sensation is regained indicates the lowest segment of the cord in which some conductivity is retained, and not, of course, that the tumour lies beneath it.) The most definite levels of loss of vibratory sense are obtained when the growth is dorsal or dorsolateral and presses upon the posterior columns of the cord.

When the extent of sensory loss has been determined as accurately as possible, it must first be reduced to terms of *segmental level of the cord*, and finally to terms of *actual level of compressing growth*: and both are best estimated from the level of the loss for sensations of pain. The final localization depends upon a suitable allowance for the obliquity with which the neurones of the second series cross the cord, and the level of compression is estimated at the number of segments cephalward which is suitable for the particular part of the cord involved (*see* p. 421).

ii. *Splanchnic.*—These features have been included in the section on symptoms referable to roots.

2. **Motor Paralyses.**—

a. Upper Neurone Type.—The level of the growth may be roughly estimated by determining the extent of the spastic paralysis present. When the most proximal paralysed muscles have been identified, the segment of cord from which they are innervated is taken as the highest showing evidence of pressure upon the pyramidal tract.

b. Lower Neurone Type.—The situation of flaccid muscular paralysis is almost diagnostic of the site of pressure upon the cord, since in the vast majority of cases it is the result of pressure upon anterior nerve-roots. Foix, however, comments upon a case where the tumour pressed upon the second, third, and fourth cervical segments, which was complicated by atrophy of the small muscles of the hand (eighth cervical). This finding he attributes to anterior radiculitis, possibly due to compression of the roots in question by the cerebrospinal fluid below the tumour. As has been pointed out, each muscle is supplied by three adjacent segments, so that for its complete paralysis a growth of sufficient vertical extent must be present.

3. **The State of the Reflexes.**—

a. Somatic Reflexes.—The hyperactivity of tendon-reflexes which is present in spastic paralysis may be utilized in arriving at the level of the growth. Many cord segments are definitely associated with a certain reflex, and if this is found to be increased the pyramidal tract must be compressed above that level. Before deciding that a reflex is increased those which are presumably unaffected should also be examined; thus a normal standard may be established for the individual. The highest point of compression of the pyramidal tract will then be indicated by the level of the segment which supplies the muscle first showing an increased tendon reflex. The method of arriving at this level is shown in *Fig.* 282. Entire absence of a given reflex, while reflexes proximal and distal to it are maintained, is even more valuable for purposes of localization, since it indicates a destructive lesion at the level of the cord subserving the reflex, provided, of course, that the paraplegia has not advanced to the flaccid stage. Thus the lower abdominal skin-reflexes may be absent although the epigastric skin-reflex and the cremasteric reflex are present.

When the lower limbs are spastic in flexion, stimulation of any part of the skin up to that supplied by the lowest part of the cord compressed may give rise to a sequence of events known as the *reflex of defence*. This reflex has been the subject of much controversy and speculation. Briefly it may be stated that it is a combination of flexion at the hip and knee, and dorsiflexion of the toes—especially the great toe; if the bladder is full, it may be emptied; profuse sweating of the anæsthetic skin may occur; and there are often extension movements of the contralateral leg if this has been flexed before the reflex is elicited (probably a return to primitive correlated movements.) The reflex is most constantly and completely obtained when the skin of the sole of the foot is the area stimulated, and its intensity is diminished the farther from this point the stimulus is applied. The latter may be tactile, painful, or thermal, and stimulation of the deeper tissues by tarsal compression or blunt pressure is also effectual. As a general rule in cases of leptomeningioma the level up to which this reflex can be evoked coincides fairly closely with the level of anæsthesia; a broad band separating the two levels is more suggestive of the presence of a diffuse pathological process such as chronic meningitis. If knee- or ankle-clonus is obtainable in the limb, it may be inhibited by pinching any part of the skin up to the level which is supplied by the lowest segment of the cord which is compressed, and determination of this level thus gives additional information as to the lower limit of the lesion.

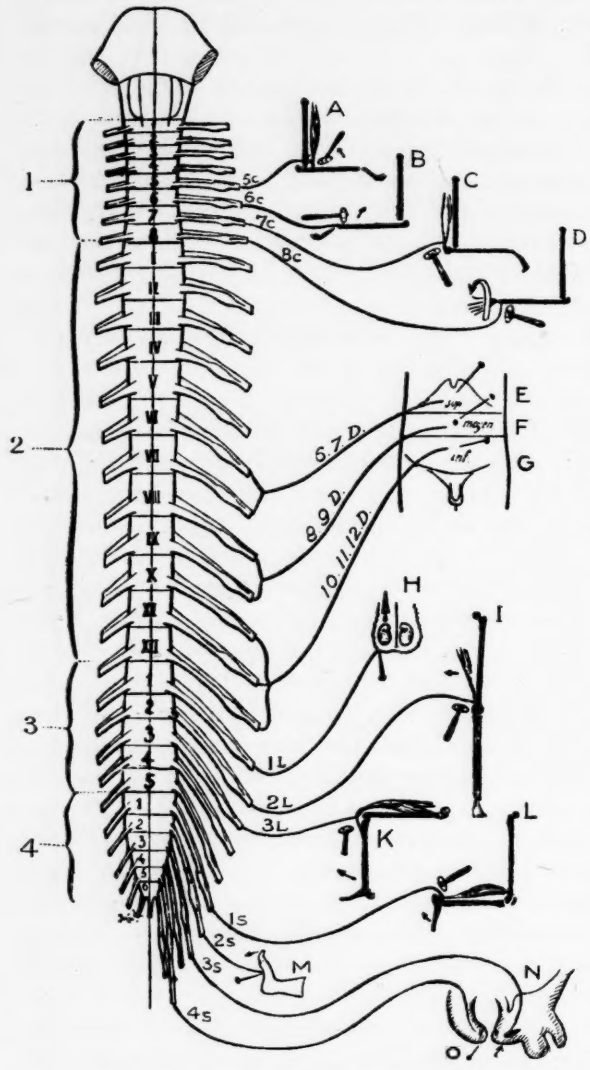


FIG. 282.—Scheme of the principal spinal reflexes, to illustrate method of determining approximate level of lesion. 1, Cervical cord; 2, Dorsal cord; 3, Lumbar cord; 4, Sacral cord. Reflexes: A, Biceps; B, Supinator; C, Elbow-jerk; D, Pronator; E, F, G, Upper, middle, and lower abdominal; H, Cremasteric; I, Adductor-jerk; K, Knee-jerk; L, Ankle-jerk; M, Plantar; N, Bulbocavernosus; O, Anal.

b. Sympathetic Reflexes.—Our knowledge of the value of these reflexes is largely derived from the work of French neurologists, and particularly of

Thomas. This observer determined the distribution of sympathetic fibres already detailed (p. 423) by using the pilomotor reflex, which is evidenced by bristling of the hairs on stimulating the skin either of the nape of the neck or of the anæsthetic area. As a guide to the level of a growth its distribution must be accepted with caution. The sudomotor reflex, obtained in the same way, is most variable and inconstant, and may result either in hyperidrosis or anidrosis. Occasionally a vasomotor reflex can be elicited by stimulating the skin of the anæsthetic area; the vasodilatation extends to the level supplied by the sympathetic fibres passing from the segment below the interruption; this may or may not coincide with the somatic sensory loss.

XVIII. DIFFERENTIAL DIAGNOSIS.

This condition must be diagnosed from: (1) *Other forms of intradural extramedullary tumour;* (2) *Extradural tumours;* (3) *Chronic myelitis and meningomyelitis;* (4) *Syringomyelia;* (5) *Osteo-arthritis;* (6) *Other miscellaneous lesions.*

1. Other Forms of Intradural Extramedullary Tumour.—

Simple Tumours.—Inflammatory growths of *tuberculous* or *luetic* origin are not uncommon in the spine. A complete examination of the cerebro-spinal fluid shows pleocytosis as well as increased protein content, and possibly a positive Wassermann reaction. There may be evidence of tuberculosis or syphilis elsewhere in the body, and the X rays may reveal associated lesions in the neighbouring vertebræ. It is wellnigh impossible to exclude other growths such as *neurofibroma, fibroma, myxoma,* and the relatively non-malignant form of glioma known as *ependymal cell glioma.* Root pains are rarely absent and usually severe in cases of neurofibroma. Softer tumours (myxoma, glioma) more frequently give rise to xanthochromia. Moreover, some gliomas and certain degenerating neurofibromas erode the bony casing of the cord, an effect which may be demonstrated radiographically. Of all simple tumours the leptomeningiomas are of the hardest consistency; thus, broadly speaking, they lend themselves to the most definite localization.

Malignant Tumours.—Of these, *sarcoma* and *glioma* are the commonest. The history is relatively shorter (occasionally as brief as seven to ten days) and the progress of the disease more acute; for such tumours grow rapidly, and moreover hæmorrhages from ill-supported vessels may at any time intensify existing features, or lead to a sudden change in the clinical picture (sudden paraplegia). The spinal fluid is apt to be yellow.

2. Extradural Tumours.—

Simple Tumours.—A *chondroma* may be identified in radiograms. *Neuro-fibromas,* and *lipomas* springing from the extradural fat, give rise to no characteristic symptoms, although the former may be associated with similar growths elsewhere in the body. Rigidity of the spine over the growth is a common feature.

Malignant Tumours.—When arising in the bony column such growths may show destruction of bone in X-ray plates of the spine. *Secondary malignant growths* in the vertebræ may be traceable to a primary focus; occasionally they may be felt from or may even reach the surface. They are apt to give

rise to symptoms of sudden transverse interruption of the cord, not from the pressure they exert but because they cause thrombosis in the vessels of the cord. A type of diffuse *sarcoma* of the dura occurs, which from its considerable vertical extent causes symptoms referable to many segments of the cord. *Multiple myelomas* may be identified in other bones, and the blood picture and urinary findings (Bence-Jones albumosuria) are helpful.

3. **Chronic Myelitis and Meningomyelitis.**—A focus of infection may be found, for example in the prostate. In the first condition, most common in the dorsal region, there is no spinal block, and pain if present is never so severe as in cases of tumour, nor is it of the root type. Chronic meningomyelitis is sometimes difficult to exclude. As a rule the clinical features in this disease suggest the presence of a lesion of considerable vertical extent, and the symptoms and signs conform to the varying anatomical relations of the lesion to the cord and nerve-roots. While block may be present, in this condition, as in myelitis, pleocytosis is present in the cerebrospinal fluid.

4. **Syringomyelia.**—In this disease the anæsthesia is of the dissociated type, and the characteristic early motor lesion is flaccid palsy of the small muscles of the hand. Such manifestations as painless whitlow, arthropathies, etc., may help to exclude cord tumour. There is no spinal block.

5. **Osteo-arthritis.**—This condition, especially frequent in the lumbar spine, may simulate cord tumour very closely. Root pains occur, and the bony outgrowths may lead to partial spinal block. Suggestive points are arthritic lesions elsewhere and the presence of foci of infection which might account for the condition. The X rays reveal the structural alterations in the spine.

6. **Other Miscellaneous Lesions.**—*Echinococcus cysts* not uncommonly form in the spinal canal, in countries where this disease is prevalent. Cysts may have been removed from other parts of the body, and the serum of the patient may show complement fixation with an echinococcus antigen.

In the region of the cauda equina *toxic neuritis* of the nerve-roots may closely mimic tumour growth. A cause for the neuritis may be found, but more frequently the diagnosis is made only after exploratory laminectomy. A dry tap is less frequently made in these cases. *Pelvic tumours* involving the nerves of the lumbosacral plexus are excluded by rectal examination. *Hæmatomyelia* and *hæmatorrhachis* have an acute onset, oftenest after trauma. In the presence of extensive cardiovascular disease, sudden development of a transverse lesion suggests the diagnosis of *thrombosis of a spinal vessel.*

XIX. OPERATIVE TREATMENT.

The technique of laminectomy is now so well standardized that it is not proposed to describe the preliminary stages of the operation. Suffice it to say that in my opinion no 'flap' or osteoplastic method of exposing the theca is superior to the ordinary procedure. The operation may be performed under local anæsthesia, either by infiltration or by blocking the nerve-roots as they emerge from the intervertebral foramina (paravertebral anæsthesia), or a general anæsthetic may be administered. If the latter is chosen, probably ether given by an intrapharyngeal tube is best. Even when a general

anæsthetic is used it is advantageous to infiltrate the operative site with a weak solution of novocain ($\frac{1}{2}$ per cent) to which a solution of adrenalin hydrochloride (1–1000) is added in the proportion of 10 drops of adrenalin to 100 c.c. of novocain solution. Such a procedure reduces bleeding and minimizes shock arising from operative trauma.

Surgical interference with the cord demands from the operator even greater gentleness than is necessary in dealing with the brain. The nerve-roots and the cord itself

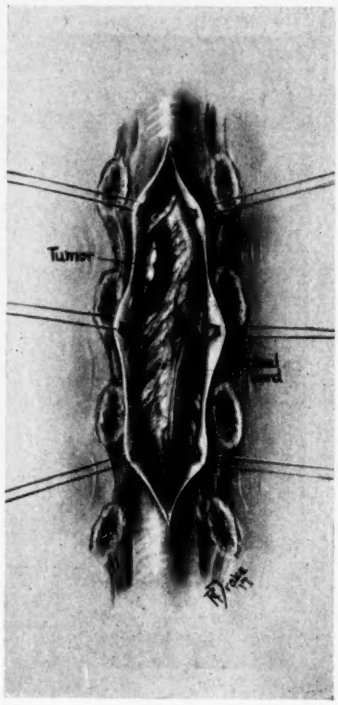


FIG. 283.—Enucleation of leptomeningioma. This was an anterolateral tumour situated between the seventh cervical and first thoracic vertebræ.

are exquisitely sensitive, and any undue handling or exposure rapidly gives rise to a severe degree of shock. This may be lessened by placing pledgets soaked in novocain solution around the cord above the tumour. Painful afferent impulses are thus interrupted, and these—according to the 'anoci-association' theory of Crile—are the most potent factor in the causation of shock.

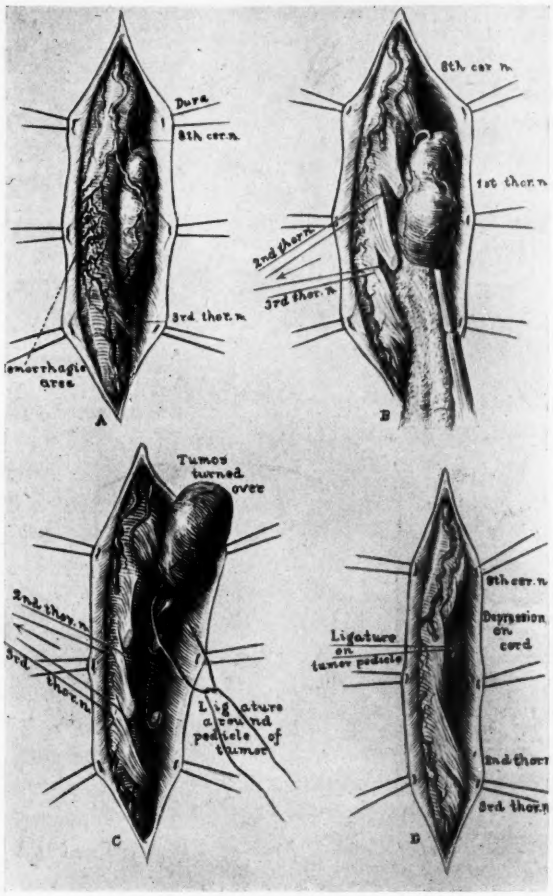


FIG. 284.—Stages in the enucleation of an anterolateral leptomeningioma. A, Exposure of growth; B, Division of spinal roots and rotation of cord, prior to the enucleation of the tumour; C, Elevation of the tumour to show the attachment of the pedicle to the dura; D, Appearance of the cord after removal of the tumour. Note the effect produced by the pressure of the latter

When the dura has been opened it may happen that the growth is not at once apparent. In such cases it is probable that the lesion is at a higher level than the segment exposed. This point may be

verified by injecting into the subarachnoid space between the third and fourth lumbar vertebræ 5·00 c.c. of a sterile 1 per cent solution of indigo-carmine in distilled water. If the tumour is below the area exposed, the dye will not readily appear about the cord. If the cerebrospinal fluid is tinted at once by the indigo-carmine, the incision should be extended upward and the bony casing of the theca removed until the tumour is reached; rarely is it justifiable to pass even the softest of probing instruments up the canal in a blind endeavour to locate the obstruction.

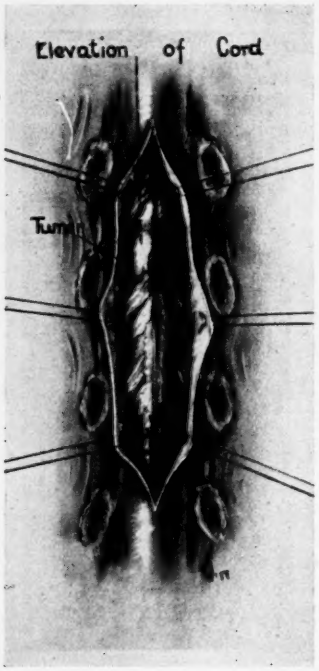


FIG. 285.—Bulging of the spinal cord, due to a leptomeningioma situated anteriorly.

When the growth is exposed it should be removed as far as possible in one mass by delicate blunt dissection with moist pledgets of wool. Care must be taken that it is not torn bodily from the important structures among which it is lying. In order to avoid this it may be necessary to remove the bulk of the growth piecemeal and to leave the removal of its capsule to the last. The most perfect hæmostasis is essential, and the subarachnoid space must be kept scrupulously free from blood. The sucker will be found most useful. Parenchymatous oozing may be checked by pressure or by applying small pieces of muscle to the bleeding surface. If it is found impossible to separate the growth from a nerve-root this should be carefully divided between fine ligatures, so that the segmental vessels passing to the cord are secured. Whenever possible adherent dura must be removed with the tumour by snipping round the latter with fine scissors; if the growth is ventral, this is not feasible because of sinuses in the dura; it may then be scraped with a spoon.

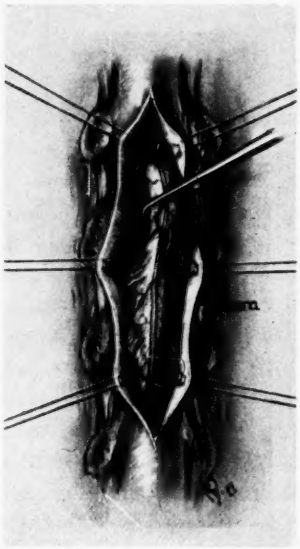


FIG. 286.—Showing depression made by anterior tumour, and the elevation of the cord necessary before enucleation of same is possible.

Occasionally it is difficult to obtain adequate access to a ventral tumour. In such cases one of the slips of the dentate ligament may be divided close to its attachment to the dura. The slip is then grasped in mosquito forceps, and by gentle traction on these the cord is rotated a little, and a better exposure of the tumour is afforded.

Before the dura is closed the field of operation must be cleansed by gentle syringing with normal saline solution at a temperature of 99° F. until this returns clear. Any dural defect may be sealed with Cargile membrane or with a fascial graft. The utmost care should be taken to close the wound firmly in layers, in order to prevent a leak of cerebrospinal fluid.

After-treatment.—The after-treatment of these cases demands especial nursing care. The insensitive skin is particularly liable to break down at the pressure points, especially if it has been injured by the unwise application of hot-water bottles. Where there has been previous bladder trouble the viscus should be drained continuously by an indwelling catheter, which need not be changed oftener than once every three days. The exhibition of hexamine, combined when the urine is alkaline with the acid phosphate of sodium, helps to prevent or combat urinary infection, and lavage of the bladder with such a chemical as mercury oxycyanide (1–4000) should be carried out night and morning. When the patient regains control of the bladder the catheter may be removed. The rectum is best emptied by an enema every second evening.

XX. PROGNOSIS.

The prognosis in cases of leptomeningioma of the spinal cord may be considered under two headings: (1) *The question of operative removal*; (2) *The question of restoration of function in paralysed areas.*

1. **The Question of Operative Removal.**—It may be said at once that leptomeningiomas of the spine lend themselves readily to removal. Usually an intracapsular enucleation can be performed, and under these favourable conditions there need be no anxiety that the growth will recur. As has been mentioned, when occurring in the spine tumours of this type do not display even the local malignancy which is a feature of certain intracranial specimens. Anatomical relations make the removal of a high cervical growth somewhat hazardous, but this may be overcome to some extent by dividing the operation into two stages—first exposure, and later removal. In other situations there is a possibility that one or two nerve-roots must be sacrificed, but the resulting anæsthesia is trivial, unless it be necessary to divide all the roots arising from three adjacent segments. The removal of several contiguous spines and laminæ does not appreciably weaken the vertebral column, unless the articular processes are encroached upon.

Of more importance is the general condition of the patient. His resistance is often lowered by a prolonged period of inanition, and frequently severe urinary infection is present. Pre-existing bed-sores may offer a portal for the entrance of infection, and his position in bed and paralysis preclude efficient ventilation of the lungs. On the other hand, it is remarkable how well these patients withstand the operation; in the Mayo Clinic series of 31 patients the immediate mortality was 9·7 per cent (3 patients). All deaths

occurred in advanced cases of the disease. One patient died of shock thirty-six hours after operation. He had had almost complete paraplegia for five months, and the cord at the level of the growth was about four-fifths of its natural size. One patient died twenty-four hours after operation. The tumour was high in the cervical region, and the cord was compressed to one-half of its natural size. One patient with complete paraplegia had had an unsuccessful laminectomy elsewhere a year before. This patient died of acute pericarditis.

2. **The Question of Restoration of Function.**—The degree of restoration of function after the careful removal of a leptomeningioma depends upon two factors: (*a*) The stage at which the operation is performed; and (*b*) The type of compression of the cord displayed. In early cases, where the conducting paths have not suffered severely, return of function is usually rapid and complete. In general it may be stated that where paralysis has been present for less than twelve months, at the very least some return of function may be confidently expected. A more definite opinion may be possible after the operation; as has been pointed out, a deep local indentation of the cord produces more permanent damage than does a longer flattening. Improvement is sometimes apparent immediately after removal of the tumour. It may be aided and hastened by careful massage, and it has been known to show itself first after so long an interval as eighteen months. Usually the first sign of recovery is the regaining of vesical and rectal control, if these have been impaired. Later there is a gradual return of muscular power, and finally sensation is restored to anæsthetic areas, although of all the functions of the cord the transmission of sensory impulses is the most likely to suffer some permanent damage. With the return of sensation trophic ulcers heal more rapidly. Reference has already been made to the possibility of the return of motor function even after a previously spastic paralysis has become flaccid, although such a favourable result is rare. On the whole it may be said with confidence that the operative treatment of leptomeningiomas of the spinal cord is equally gratifying to surgeon and patient.

XXI. CASE HISTORIES.

The following are the histories of five patients suffering from spinal leptomeningioma, whose examination and treatment I was privileged to follow at the Mayo Clinic. For the opportunity of doing so I am much indebted to Drs. Shelden and Adson of the Neurological Department.

Case 1.—**High cervical leptomeningioma in a male, age 32. Extirpation (partial). Recovery.**

HISTORY.—Four months previous to registration the patient began to have headache in the right parieto-occipital region, which radiated to the right occiput and neck. This was constant, reached its maximum intensity in the early hours of the morning, and abated about noon. At the same time he found that he had difficulty in starting the act of micturition, and that the stream of urine lacked force; and also that his bowels moved with increasing difficulty. A month later he noted that he could not move his left hand and arm as he wished, and a little later had the same difficulty with his left foot, so that he became unsteady when walking. There was also a slight ache along the inner border of his left arm. For two months he had had analgesia and thermanæsthesia of the right arm, right side of the body,

and right leg; this was accidently discovered as he was taking a warm bath. Atrophy of the nuchal muscles on the left side was observed six weeks previously, and for the same time there had been a tingling sensation in the right hand, beginning in the fifth finger. There had been some twitching movements of the left index finger, and the left arm became flexed when he yawned (p. 434). For two months the headache had been accompanied by vomiting, which was not associated with nausea.

Essential Neurological Findings.—The right pupil was larger than the left. The optic fundi were normal. The muscles on the right side of the body were normal. On the left side the muscles were paralysed in the following degrees:* Interossei, − 3 − 4; thenar and hypothenar, − 2 − 3; flexors and extensors of arm, − 2 − 3; supinators and pronators, − 3 − 4; abdominal muscles, − 2; muscles of leg, − 1 − 2. Tonus in these affected muscles was + 1 + 2. The left nuchal muscles were atrophied, + 2.

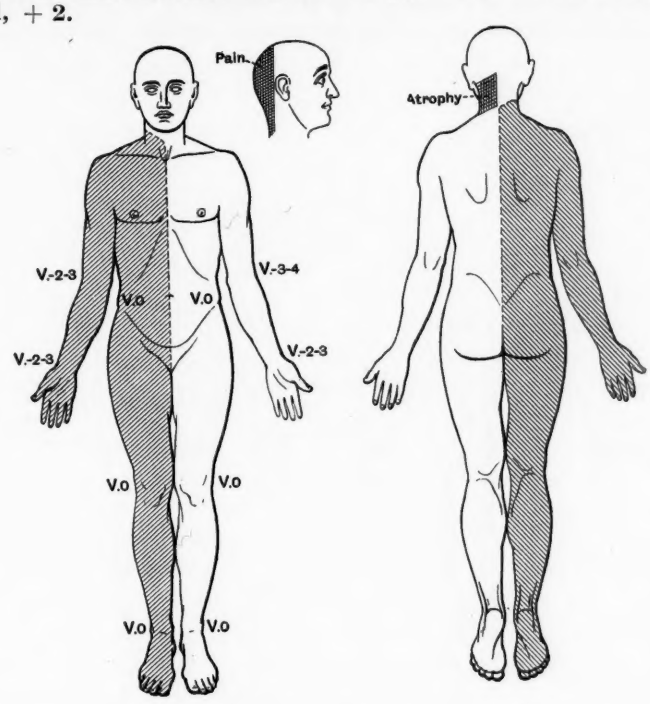


Fig. 287.—*Case* 1. Sensory findings. There was complete analgesia and thermanæsthesia over the shaded area. V, Vibratory sense.

All the tendon-jerks of the left arm were increased + 2 + 3, as were also the jerks of both right and left legs. On both sides the great toe was dorsal-flexed on stimulating the sole of the foot. The abdominal reflexes were absent on both sides. The gait was slightly spastic, the left leg being specially affected. There was some dysdiadochokinesia and dysmetria of the left arm.

Loss of perception of painful and thermal stimuli was complete over the right side of the body, below the level of the cutaneous cervical nerve. Tactile sense was intact. The sense of vibration was normal in the pelvis and lower extremities, but was diminished − 2 − 3 − 4 in the arms. (*Fig.* 287.)

---

* In the Mayo Clinic the degree of all processes is graded from 1 to 4. Thus − 4 would indicate complete palsy of a muscle; + 2 a moderate increase in tonus; − 1 a slight blunting of sensation. For the normal condition 0 is used. This system will be adhered to throughout these case reports.

OPERATION.—Under paravertebral anæsthesia Dr. Adson removed the spines and laminæ of the upper four cervical vertebræ, and part of the occipital bone. The tumour was dorsolateral and was situated opposite the first cervical root on the left side. It measured 3 × 2 × 1 cm., and when removed exposed an area of about 15 mm. diameter, ? a cross-section of an intramedullary portion. This was not excised. The patient had an uneventful convalescence.

Case 2.—**High cervical leptomeningioma in a male, age 25. Extirpation. Death eleven weeks later from internal hydrocephalus and hydronephrosis.**

HISTORY.—Ten years previously the patient had had an injury to the back, between the shoulders. At that time the back was painful for six to eight weeks. The following year the pain recurred, but thereafter he was well for seven years. Then he began to have aching pain in the left shoulder and forearm, which was accompanied by a feeling of numbness in the fingers of the left hand and in the left forearm. This was followed by a slow progressive spastic weakness of the left arm.

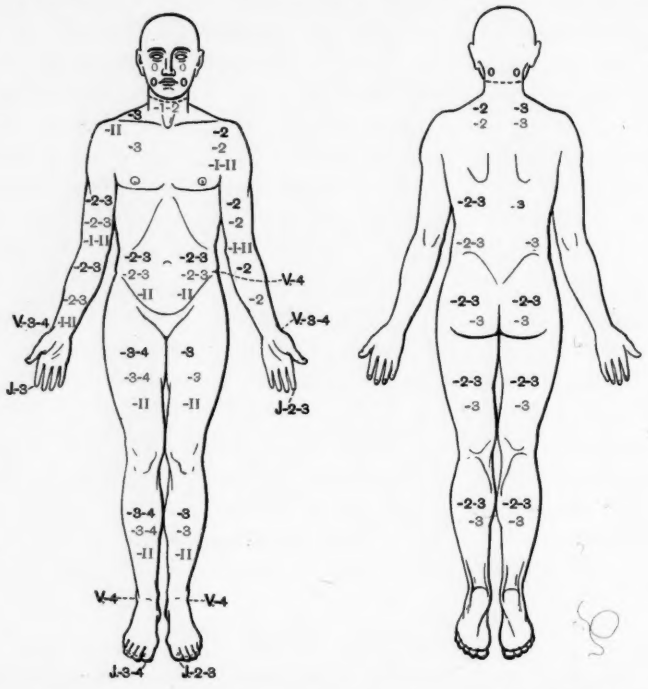


FIG. 288.—*Case* 2. Sensory findings. Black Arabic, Tactile; Red Arabic, Pain; Red Roman, Temperature; V, Vibratory sense; J, Joint sense.

Six months later the pain became very severe, and now radiated to the left side of the neck, and down the left arm to the fingers. About eight months after the beginning of the illness he noted some loss of strength, loss of control, and awkwardness of the left leg, together with a numb feeling in this extremity. Twelve months later the right arm and leg became similarly affected, while the condition of the left arm and leg improved somewhat. Recently on one or two occasions he had lost control of his urine, and his bowels had become increasingly constipated.

ESSENTIAL NEUROLOGICAL FINDINGS.—The muscles of both arms were weakened, those of the right − 2 − 3, those of the left − 2. All the muscles of the right lower extremity were weak (− 1 − 2), and there was a similar degree of weakness of the muscles of the left pelvic girdle. The tendon-jerks were increased in both arms (+ 1 + 2) and both legs (right + 2 + 3, left + 3 + 4). The abdominal reflexes were absent. On both sides the great toe was dorsiflexed on stimulating the sole

of the foot. The gait was spasmodic, and inco-ordination and dysmetria were marked on both sides.

Below the level of the cutaneous cervical nerve there was loss of perception of all forms of sensation, which varied in intensity from − 2 in the arms, − 2 − 3 over the trunk, − 3 in the thighs, to − 3 − 4 in the legs. The details are shown in *Fig.* 288. Examination of the cerebrospinal fluid revealed the Nonne syndrome, no xanthochromia, and a very slight response to jugular pressure.

Operation.—Under paravertebral anæsthesia Dr. Adson removed the spines and laminæ of the upper four cervical vertebræ. The tumour was dorsolateral, 30 × 15 mm., and situated opposite the second and third cervical vertebræ. It was removed with some adherent dura. Three weeks after operation the patient suddenly developed right hemiplegia with aphasia, and died two months later. The post-mortem examination showed internal hydrocephalus and hydronephrosis.

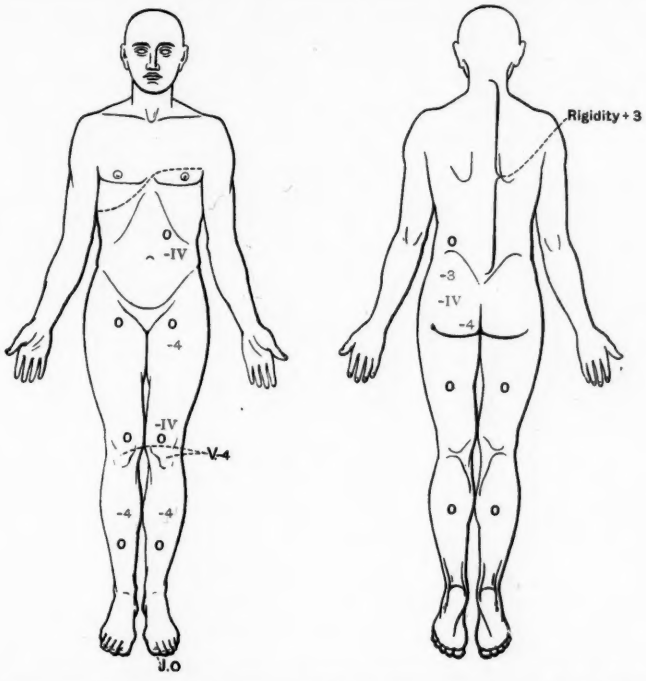


Fig. 289.—*Case* 3. Sensory findings. Black Arabic, Tactile; Red Arabic, Pain; Red Roman, Temperature; V, Vibratory sense; J, Joint sense.

Case 3.—**Upper dorsal leptomeningioma in a female, age 48. Extirpation. Recovery.**

History.—For four years the patient had felt pain in the third and fourth intercostal spaces, radiating from the back round to the left breast. The pain was worse if her spine was jarred, and also in the morning on getting up. After three years this pain became very severe, and she also felt pain up and down the whole dorsal and lumbar regions in the muscles on either side of the spine, which eventually became so rigid that she was unable to tie her shoes. For some months she had been spending her nights alternately walking and sitting, in an effort to obtain relief from pain, and she had lost a good deal of sleep. Eleven months previous to her registration she had a series of plaster casts applied to the spine elsewhere. The casts were uncomfortable, especially when she was lying down. Her worst pain was in the morning on first rising, and at night she had throbbing pain round the third intercostal space under the axilla to the left breast; frequently she had to leave her bed and walk about.

Six months previously she began to feel better, and four months later she had the last cast removed. A few hours after its removal she noticed a numbness across her abdomen which had not been present before. That night she had little pain, but she noted her legs were also numb. In the morning her old pain had returned, the numbness had extended to the feet, and her legs were 'not working properly'. These features had remained stationary; her pain was readily started by jarring movements of the spine and by coughing and sneezing. There had been no sphincteric disturbances.

ESSENTIAL NEUROLOGICAL FINDINGS.—There was no muscular paralysis. The tendon-jerks on both sides of the body (arms and legs) were increased + 1 + 2, and there was a bilateral dorsal response of the great toe on stimulating the sole of the foot. The abdominal reflexes were absent. Romberg's test was positive. The tactile sense was normal, but below the level of the fourth rib on the left side and the sixth rib on the right side there was complete analgesia and thermanæsthesia.

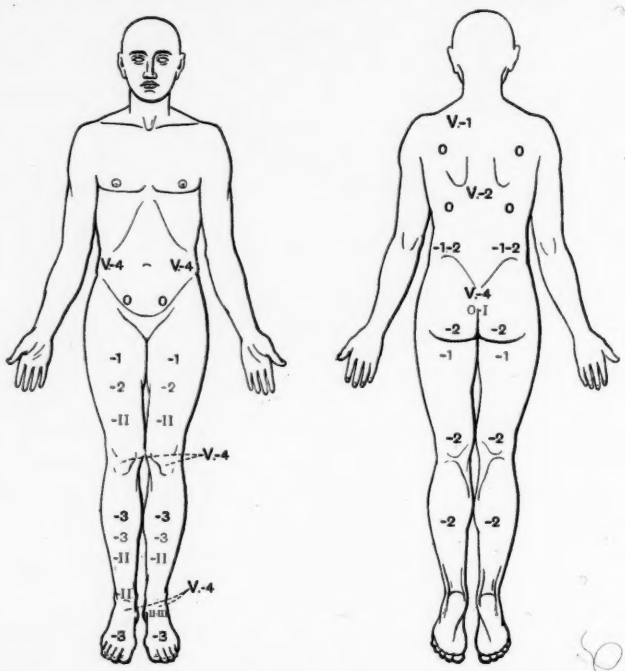


FIG. 290.—*Case* 4. Sensory findings at first examination. Black Arabic, Tactile; Red Arabic, Pain; Red Roman, Temperature; V, Vibratory sense.

The joint sense was normal in the legs. The details are shown in *Fig.* 289. Examination of the cerebrospinal fluid revealed a normal colour, no increase of protein, and a poor response to jugular compression.

OPERATION.—Under paravertebral anæsthesia and a little ether Dr. Adson removed the spines and laminæ of the upper six dorsal vertebræ. The tumour was found on the left anterolateral aspect of the cord, opposite the fourth and fifth dorsal vertebræ. It was fusiform, 4 × 2 cm. in size, and it had compressed the cord to half its normal size. It was attached to the dura in the vicinity of the point of exit of the fourth dorsal nerve-roots. It was removed completely. Convalescence was uneventful.

Case 4.—**Mid-dorsal leptomeningioma in a female, age 65. Diagnosis at first obscure. Tumour removed later. Recovery.**

HISTORY.—This patient first registered at the Mayo Clinic two years previously. For six years she had had weakness of both lower extremities, with tingling and

numbness. Three years later the weakness began to progress, and there were occasional spasms of the muscles of the legs. During the whole of the illness there had been some difficulty in controlling the bladder, and for the last year and a half this had been markedly increased. A year previously she began to have a 'girdle sensation' around the lower abdomen, and this was still present. Six months later pain appeared. At first this came on in the early morning, and was relieved if she got up and sat in a chair. Lately it became progressive and was felt by day as well as by night. There were two painful areas: one just to the right of the umbilicus, crossed by the 'girdle sensation' and about the size of the palm of the hand, and another about two inches in diameter over the right sacro-iliac joint.

Essential Neurological Findings.—There was slight weakness of the muscles of both lower extremities ($-1-2$). The tendon-jerks in these were increased ($+1+2$), and there was a marked bilateral dorsal response of the great toe on stimulating the sole of the foot. The abdominal reflexes were absent. The gait

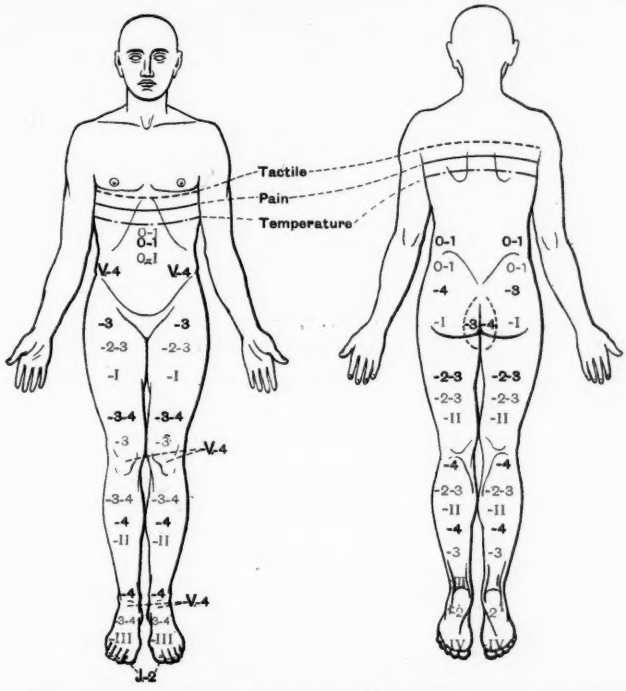


Fig. 291.—*Case* 4. Sensory findings at second examination, two years after *Fig.* 290. Black Arabic, Tactile; Red Arabic, Pain; Red Roman, Temperature; V, Vibratory sense; J, Joint sense.

was ataxic, and Romberg's sign was positive. The sensory changes are best studied from *Fig.* 290.

Diagnosis.—The diagnosis lay between hypertrophic arthritis of the dorsal spine, arteriosclerosis of the central nervous system, and tumour of the cord. Exploratory laminectomy was advised but declined.

Subsequent History.—After leaving the clinic the weakness and numbness of the legs increased, and the 'girdle sensation' became crushing in type. She got about on crutches. Two years later, when she was re-examined, she had continuous aching pain in both lower extremities, worst at the joints. Four months previously her legs had given way and she had sprained her ankle; she had not been able to walk or stand since.

The weakness in the muscles of the lower extremities had increased to $-3-4$ on the right side and to $-2-3$ on the left side. The reflexes were as before. A

definite sensory level was now present (*Fig.* 291), and these findings should be compared with those of two years previously. The cerebrospinal fluid was clear, and responded but poorly to jugular compression.

OPERATION.—At the laminectomy, performed under local anæsthesia, Dr. Adson found an anterolateral tumour opposite the seventh dorsal vertebra, 2 cm. in diameter. The cord was reduced to one-third its normal size. Convalescence was uneventful.

Case 5.—**Low dorsal leptomeningioma in a female, age 50. Extirpation. Some improvement.**

HISTORY.—Seven years previously, in the spring, the patient began to suffer from severe pain in the left hip, especially after lifting a weight or after a hard day's work. Later this pain spread down to the posterior aspect of the left knee, and finally to the left foot. By the following summer the condition had cleared up,

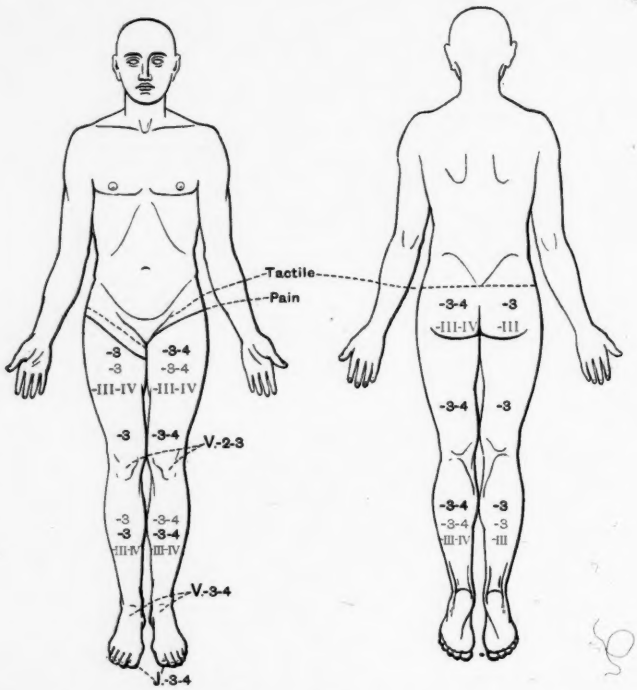


FIG. 292.—*Case* 5. Sensory findings. Black Arabic, Tactile; Red Arabic, Pain; Red Roman, Temperature; V. Vibratory sense; J. Joint sense.

but in the autumn the pain returned with greater severity. A year or so later she developed dull pain in the left upper quadrant of the abdomen; at times this radiated to the back on the same side. Five years previously, while the hip pain was still present, she noted weakness and loss of control of the left leg, and at the same time she began to suffer from pain in the right hip. Three years later the paralysis had increased to such an extent that she lost the use of both legs. For two or three years she had had difficulty in starting the flow of urine, and also progressive constipation.

ESSENTIAL NEUROLOGICAL FINDINGS.—There was weakness of the muscles of the pelvic girdle on both sides (– 2 – 3), and complete paralysis of the remaining muscles of the lower extremities (– 4). The tendon-jerks of the legs were increased, and there was bilateral dorsal flexion of the great toes on stimulating the soles of the feet. The sensory changes were as shown in *Fig.* 292. The cerebrospinal fluid

showed xanthochromia, increased protein content, and no response to jugular compression.

OPERATION.—Dr. Adson removed the spines and laminæ of the dorsal vertebræ from the eighth to the twelfth. The tumour involved the eleventh and twelfth dorsal posterior nerve-roots, measured 2 × 1·5 cm., and had compressed the cord to one-third its normal size. Convalescence was uneventful, but improvement slow. One month after operation the sensory paralysis was a little better, but the urine was less easily controlled.

Mr. Irish, photographer at the Mayo Clinic, is responsible for *Figs.* 231–237, 271, 272, 283–286 (all pre-existing photographs which were suitable), 227–229, 238, 239, 241–250, 252–256, 264, 267 (sections prepared by me to illustrate this paper, from material provided by the Mayo Clinic), and 258, 259, 261, 263, 266 (from material obtained from an experiment I made upon an animal). Mr. Kirkpatrick, of the Pathological Department, Glasgow University, photographed the remainder. *Figs.* 226, 240, 251, 260, 262, 269, 270 are from sections I prepared from material provided by the Mayo Clinic. *Fig.* 230 is from Dr. Frazier's book, *Surgery of the Spine and Spinal Cord* (Appleton). *Fig.* 257 is a diagram I modified from a figure by Professor Elliot-Smith. *Figs.* 265 and 268 are from the experiment mentioned above. *Fig.* 273 I constructed from data in a paper by Mr. Barrington. *Figs.* 275–280 I constructed from notes of a lecture by Dr. Stookey. *Fig.* 281 is from a paper by Drs. Cushing and Ayer, and *Fig.* 282 is from a paper by Dr. Lévy-Valensi. For the sections from which *Figs.* 267, 269, and 270 are taken I am indebted to Dr. J. W. Kernohan, Neurological Pathologist to the Mayo Clinic. For the use of the remaining pathological material, with the exception of that obtained from an experiment upon an animal, my thanks are due to Dr. H. E. Robertson, Pathological Anatomist to the Mayo Clinic.

Dr. F. C. Mann, Director of the Experimental Laboratory, Mayo Clinic, kindly gave me facilities for obtaining fresh material to illustrate the histological appearances in compression of the cord. Under ether anæsthesia and aseptic technique I removed the spines and laminæ of the sixth and seventh dorsal vertebræ of an adult dog. I then pushed a cylinder of bone wax, measuring 1·5 × 0·5 cm., between the arch of the fifth dorsal vertebra and the dura, and closed the wound in layers. After a period of six weeks, during which the animal gradually developed total anæsthesia below the level of the ninth or tenth dorsal segment, it was again anæsthetized. I now removed the cord for a length of 4 cm. above and below the site of compression, while the dog was alive; in this manner the circulatory phenomena were well preserved. Suitable lengths of cord were then fixed at once in several reagents, according to the manner in which they were to be stained. The animal was killed while under the anæsthetic.

BIBLIOGRAPHY.

The following list includes the majority of the more recent papers which have been consulted in the preparation of this essay. When it has been impossible to refer to the original paper the title has been marked with an asterisk, and the source by which I became aware of its contents has been stated.

ADSON, A. W., *Jour.-Lancet*, 1920, xl, No. 22.
ADSON, A. W., *Minnesota Med.*, 1924, Feb., 79.

ADSON, A. W., *Northwest Med.*, 1925, July.
AYER, J. B., *Arch. of Neurol. and Psychiat.*, 1919, ii, 158.
AYER, J. B., *Ibid.*, 1922, vii, 38.
AYER, J. B., *Ibid.*, 1923, x, 420.
AYER, J. B., *Jour. Amer. Med. Assoc.*, 1923, Aug. 4.
BABINSKI, *Rev. neurol.*, 1922, xxxviii, 1049.
BARRÉ, J. A., *Presse méd.*, 1923, xl, 449.
BARRINGTON, F. J. F., *Med. Sci.*, 1921, Dec.
BLAND-SUTTON, Sir J., *Tumours Innocent and Malignant*, 1922, Cassell.
CARMAN, R. D., and DAVIS, K. S., *Radiology*, 1924, Sept.
CUSHING, H., *Brain*, 1922, xlv, 282.
CUSHING, H., and AYER, J. B., *Arch. of Neurol. and Psychiat.*, 1923, x, 167.
CUSHING, H., and WEED, L. H., *Johns Hop. Hosp. Bull.*, 1915, Nov., 367.
DANDY, W. E., *Ibid.*, 1922, xxxiii, 190.
DANDY, W. E., *Ann. of Surg.*, 1925, Jan.
DILLER, T., and GAUB, O. C., *Pennsylvania Med. Jour.*, 1920, xxiii, 392.
ELMAN, R., *Johns Hop. Hosp. Bull.*, 1923, xxxiv, 99.
ELSBERG, C. A., *Amer. Jour. Med. Sci.*, 1920, clix, 194.
ELSBERG, C. A., *Arch. of Neurol. and Psychiat.*, 1921, v, 64.
ELSBERG, C. A., *Surg. Gynecol. and Obst.*, 1921, xxxiii, 670.
ELSBERG, C. A., *Amer. Jour. Med. Sci.*, 1923, clxix, 719.
ELSBERG, C. A., and STOOKEY, B., *Arch. Neurol. and Psychiat.*, 1922, viii, 502.
EWING, J., *Neoplastic Diseases*, 1919, W. B. Saunders Co.
FAURE-BEAULIEU, and DE MARTEL, T., *Bull. et Mém. Soc. méd. Hôp. de Paris*, 1924, July 3, 979.
FOIX, C., *Rev. neurol.*, 1923, i, 610.
FRAZIER, C. H., *Surgery of the Spine and Spinal Cord*, 1918, Appleton.
FRAZIER, C. H., and SPILLER, W. G., *Arch. Neurol. and Psychiat.*, 1922, viii, 454.
*FROIN, M. G., *Gaz. des Hôp.*, 1903, lxxvi, 1005. (Quoted by all writers on the physical state of the cerebrospinal fluid.)
GILL, J. M., *Med. Jour. of Australia*, 1921, Sept. 10, 201.
HAMMES, E. M., *Arch. of Neurol. and Psychiat.*, 1924, xi, 82.
JACOB, C., and BORT, *Mitteil. a. d. Grenzgeb. d. Med. u. Chir.*, 1920, xxxii, 454.
JACOBAEUS, H. C., *Act. Med. Scand.*, 1921, lv, 555.
LAROCHE, G., *Presse méd.*, 1922, July 8, 583.
LÉVY-VALENSI, J., *Paris méd.*, 1922, 45 and 89.
MAAS, O., *Med. Klinik*, 1924, xx, 213.
MALLORY, F. B., *Jour. Med. Research*, 1919, xli, 349.
MARINESCO, G., *Rev. neurol.*, 1919, xxxv, 257.
MEDICAL RESEARCH COUNCIL, *Injuries of the Spinal Cord and Cauda Equina*, 1924, Special Report Ser. 88.
MIXTER, W. J., *Boston Med. and Surg. Jour.*, 1922, clxxxvi, 276.
MIXTER, W. J., *Jour. Amer. Med. Assoc.*, 1923, lxxxi, 2166.
MORGAN, R., *Med. Jour. of Australia*, 1920, ii, 533.
MOUZON, J., *Paris méd.*, 1923, Dec. 8, 471.
NAFFZIGER, H. C., *Surg. Clin. N. Amer.*, 1922, April, 363.
NEUHOF, H., *Ibid.*, 1921, Dec., 1699, 1705.
*NONNE, M., *Deut. Zeits. f. Nervenheilk.*, 1910, xl, 161. (Quoted by all writers on the physical state of the cerebrospinal fluid.)
OTT, W. O., and ADSON, A. W., *New Orleans Med. and Surg. Jour.*, 1923, lxxvi, No. 4.
PARKER, H. L., *Amer. Jour. Med. Sci.*, 1922, clxiii, 342.
PARKER, H. L., *Jour. Nerv. and Ment. Dis.*, 1922, lvi, No. 5.
PAULIAN, D. E., *Bull. et Mém. Soc. méd. Hôp. de Paris*, 1921, xlv, 878.
PETRÉN, K., and PETRÉN, G., *Acta Med. Scand.*, 1923, lix, 595.
*QUECKENSTEDT, *Deut. Zeits. f. Nervenheilk.*, 1916, lv, 325. (Quoted by all writers on the physical state of the cerebrospinal fluid.)
RENNIE, G. E., *Med. Jour. of Australia*, 1921, March 5, 185.
SARGENT, P., *Brit. Med. Jour.*, 1920, Jan. 10.
SCHALLER, W. F., *Arch. of Neurol. and Psychiat.*, 1919, i, 77.
SCHALLER, W. F., and GILLMAN, *Ibid.*, 1923, x, 512.
SCULLY, F. J., *Ibid.*, x, 83.
SELLING, L., *Ibid.*, 1922, viii, 27.
SICARD, J. A., HAGUENAU, and LAPLANE, L., *Rev. neurol.*, 1924, Jan.
SICARD, J. A., and LAPLANE, L., *Bull. et Mém. Soc. méd. Hôp. de Paris*, 1923, xlvii, 1389.
SICARD, J. A., PARAF, J., and LAPLANE, L., *Presse méd.*, 1923, Oct. 24, 885.

STEWART, Sir J. P., *Diagnosis of Nervous Diseases*, 1924, Arnold.
STEWART, Sir J. P., and RIDDOCH, G., *Rev. neurol.*, 1923, i, 566.
STOOKEY, B., *Arch. of Neurol. and Psychiat.*, 1923, x, 519.
TASCHENBERG, E. W., *Münch. med. Woch.*, 1921, lxviii, 612.
*THOMAS, A., *Le Réflexe pilomoteur*, 1922, Masson et Cie. (Summarized by Lévy-Valensi, loc. cit. supra.)
THORBURN, Sir W., *Brit. Med. Jour.*, 1922, Jan. 14.
THORBURN, Sir W., *Lancet*, 1922, Dec. 23.
WEED, L. H., *Johns Hop. Hosp. Bull.*, 1915, xxvi, 367.
WEED, L. H., *Anatom. Rec.*, 1915–16, x, 475.
WEED, L. H., *Ibid.*, 1917, xii, 461.
WEED, L. H., *Contributions to Embryology*, No. 14, Carnegie Institute of Washington, Publication 225, 1917.
WEED, L. H., *Johns Hop. Hosp. Bull.*, 1920, Oct., 343.
*WIDERÖE, S., *Norsk. Mag. f. Laege.*, 1921, lxxxii, No. 7. (Abstr. *Jour. Amer. Med. Assoc.*, lxxvii, 826.)
WIDERÖE, S., *Zentralb. f. Chir.*, 1921, xlviii, 394.

RANULA.

By DUNCAN C. L. FITZWILLIAMS, C.M.G., London.

Ranula is a loose term inherited from bygone days, distributed widely over the world, and one which we shall probably never be rid of; but it is a term in medicine which cannot be defined and has no scientific meaning. It has been applied to all cystic swellings of the floor of the mouth whatever their form or origin. Dermoid swellings, swellings in connection with calculi of the salivary glands, acute swellings, traumatic swellings, parasitic swellings, swellings below the jaw, and even below the hyoid bone in connection with the thyroid gland, have all been included under the term ranula.

Fig. 293.—Cat with ranula (*Hobday*).

The actual connotation of the term ranula even is uncertain—whether it refers to the croaking voice caused by the tumour likened to that of a frog, as some assert, or refers to the glistening appearance of the tumour which resembles the belly of the frog, as Charles Bell thought, is unknown. Some have thought the swelling is like the head of a little frog, the openings of Wharton's duct being its eyes, and others again have likened the glairy fluid evacuated to the jelly-like substance in which the eggs of the frog are found. Ranulæ are found quite commonly among the lower animals (*Fig.* 293).

Many attempts have been made to confine the term to certain swellings, but none have succeeded. Many attempts have been, and are still being, made to attribute all forms of ranulæ to one cause. Fleischmann thought he had discovered a bursa which he said was the one and only cause of ranulæ; other observers, like Recklinghausen, suggested that the origin of all ranulæ was Blandin's gland, and lately Thompson published a paper in the *Annals of Surgery* describing as the one and only cause a persistence of the cervical sinus in connection with the branchial clefts. There is no one and only cause of these swellings. Cases will be quoted to show that ranulæ may take origin in the mucous glands, the sublingual gland, Blandin's gland, and in the submaxillary gland. There is a large class of ranulæ which I suggest may

start in one or other of these organs, but in which one at the moment is doubtful. These are ranulæ with more or less extensive prolongations to the neck or face.

CYSTIC SWELLINGS OF THE MUCOUS AND OF THE SUBLINGUAL GLANDS.

These we must take together, as we are unable to differentiate them. There is no reason we know of why the mucous glands, which are numerous under the tongue, should be more liable to become cystic than they do elsewhere. On the other hand, we see them cystic frequently upon the lips and cheeks, and very seldom on the dorsum of the tongue. The tissues under the tongue are soft and lax, and therefore we may suppose that the cysts are liable to attain a larger size here than they do elsewhere. Lockwood published the following case, which must have originated in a mucous gland, as there was no salivary action found on carefully testing the fluid :—

Case 1.—A girl, age 14, had a typical ranula below the right side of the tongue which had been noticed for two months. The salivary ducts were free and discharged saliva. A piece was snipped from the wall and 2 drachms of the contents, which were a tenacious, yellow, transparent fluid, slightly alkaline, were saved. The fluid was soluble in distilled water, and became white and opaque with precipitate on the addition of acetic acid. Perchloride of iron produced no claret reaction, so that no sulphocyanide of potassium was present. Added to starch and kept for some time at a gentle heat, no conversion into glucose was obtained. It appeared to consist of pure mucin. It seemed probable that the cyst was a distended sublingual mucous gland.

Many of the cysts, however, are not of this character, and are probably due to distention of one of the ducts of the sublingual gland. Claude Bernard made cysts experimentally by obstructing the duct of Rivinus, and the work of Suzanne showed that the ducts of the sublingual gland were very irregular. Baker in 1871, at a time when all ranulæ were supposed to originate in the dilatation of Wharton's duct, drew attention to the fact that in many cases a probe could be passed along this duct, which had nothing whatever to do with the swelling. He reported in detail five cases in which the fluid of the ranula was nothing like submaxillary saliva. He also stated that obstruction of Wharton's duct produced symptoms quite unlike those of a ranula. His cases may have originated from obstruction to some of the ducts of the sublingual gland. Many of the cysts found in this region are undoubtedly of this origin. This form of ranula appears as a small glistening tumour under the tongue, and is so familiar to everyone that no ordinary case need be quoted. Weeden Cooke reported one which seems to have been peculiar :—

Case 2.—An old woman had had a ranula for many years, which had grown to be the size of an orange. If she kept it in her mouth it protruded one cheek in the most unsightly manner, and when allowed to hang out of the mouth it was like a transparent jelly-bag. She was able to talk and eat with but slight inconvenience. She steadily refused all operations, from snipping out a piece of the wall to touching it with potassa fusa.

If a piece of the wall of these cysts is examined under the microscope, mucous or secreting membrane is always found. No case has been reported

in which the cyst was lined with endothelium. This is important in view of the statements made from time to time that these cysts originate in a bursa in this neighbourhood.

CYSTS OF BLANDIN'S GLAND.

Blandin's gland is small and not of great importance. Only a few cysts of this gland have been reported. Eve noted one as follows :—

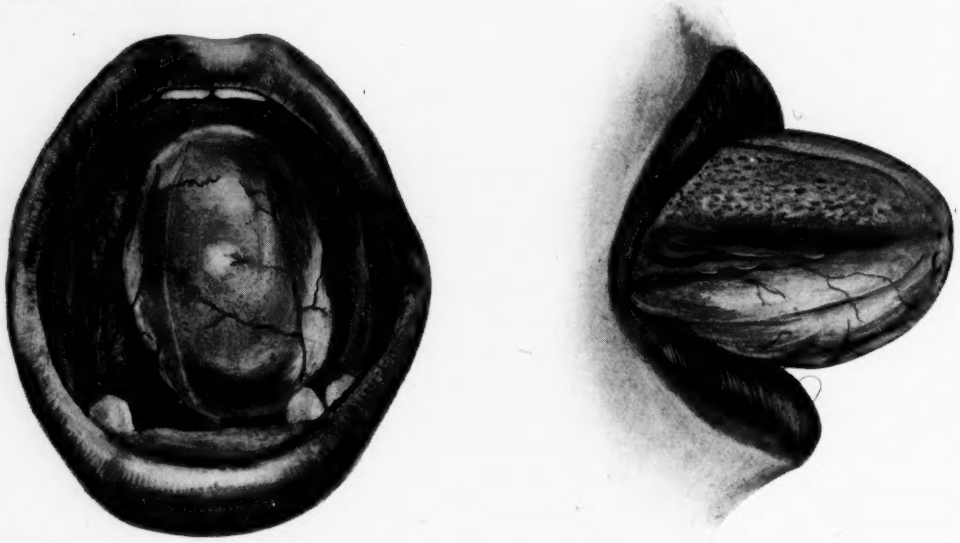
Case 3.—A ranula from the walls of which projected small glands of mucous structure. The fluid was very viscid, and gave no reaction to the tests for sulphocyanide of potassium. It had no connection with Wharton's duct.

He thought that this cyst was the ordinary type of ranula.

Von Recklinghausen reported a similar case as a cyst of Blandin's gland.

Curtis reported :—

Case 4.—A woman of 25, who had noticed a swelling for four months near the tip of the tongue on the left side. This disappeared, but soon afterwards a similar swelling appeared upon the right side. The tumour was elastic, purplish, 1 in. long by ½ in. broad. It was aspirated through a thick needle, but nothing came out. On incision, mucous fluid was obtained. It was fully opened, and the lining membrane was sewn to the mucous membrane.
(*Figs.* 294, 295.)



FIGS. 294, 295.—Curtis's case, made from a coloured drawing in Greenwich Hospital.
(*By kind permission.*)

Ramon Tejada Aguirre also reported one :—

Case 5.—The patient, 13 years old, had a congenital tumour at the tip of the tongue measuring 6 by 4–5 by 3–5 cm., slightly fluctuant. Aspiration drew some thick, white, viscid fluid, without odour, and with the characteristics of mucous fluid. Only liquid and soft food could be taken ; mastication was impossible. There was marked hyperthesia of the tongue in the region of the tumour, especially when the warm fluids were taken. The patient suffered from attacks of suffocation during sleep. It was diagnosed as a cyst of Blandin's gland. The mass was removed and recovery followed.

A congenital case was reported by Foderl in a stillborn child who had a large cyst near the tip of the tongue.

RANULÆ IN CONNECTION WITH THE SUBMAXILLARY GLAND.

The submaxillary being the largest and most important gland in the region, it is not surprising to find that it gives rise to many clinical conditions related to ranula. There are congenital ranulæ, acute ranulæ, traumatic ranulæ, and ranulæ due to the gradual occlusion or blocking of Wharton's duct.

Congenital Ranulæ.—In former days many dermoid cysts were included as congenital ranulæ, but I have eliminated these. Dr. Muller, in a paper read before the Moscow Medical Society, said that among 80,000 children observed in the Moscow Foundling Hospital only four or five cases of congenital ranulæ were known. The condition therefore is rare, and only about twenty cases have been known ; but doubtless many cases have not been published. One came under my notice at Paddington Green Children's Hospital not long ago. In nearly every case there has been either a complete or a partial occlusion of the termination of Wharton's duct. In most cases the child has been unable to take the breast, probably on account of the pain incommoding the movements of the tongue ; in one case the child died soon after birth, so that the condition could be investigated. The following excellent example may be quoted :—

Case 6.—A boy 3 weeks old, in whom a small tumour had been noted soon after birth ; sometimes there was difficulty in suckling, swallowing, and breathing. The swelling was transparent, and crossed the frænum slightly. There was no trace of Wharton's duct upon the right side, and the submaxillary gland upon that side was swollen. The opening of the duct was present on the left side. The tumour was situated along the course of the duct. (Guinard.)

Stolts's case was as follows :—

Case 7.—" The point of the tongue was lifted and directed to the right side by a whitish transparent tumour on the under surface of the frænum, which was obliterated." " The infant cries whenever it takes the breast, the voice is altered, and there is difficulty in breathing."

Other cases have been recorded by Richer (two cases), by Lannelongue (whose case died), Guyon, Blot, Panas, Giraldès (three cases), Guéniot, and Deschamps. In the last a jet could be expressed from the mouth of the duct by pressure on the floor of the mouth. The cyst was opened and a horsehair passed into it through the narrowed opening of the duct. In Lombard's case the child's face was violet-coloured and the tumour actually protruding from the mouth. The cyst was punctured and the child relieved.

In the *Bull. Gén. der Thèrapeutique*, 1862, lxiii, 316, two cases of congenital ranula are mentioned ; in one of which there was a bluish swelling under the tongue and the child refused the breast, but it swallowed well from a spoon. The child took the breast at once after the swelling had been punctured.

In most of the cases it was evident that Wharton's duct was blocked, closed, or stenosed, and did not admit the passage of saliva even when citric acid or vinegar was placed upon the tongue. Other congenital cases, however,

are recorded in which the origin of the tumour has not been so evident. Stephen Paget reported one of the best examples under the heading of "Congenital Cyst under the Tongue" (*Figs.* 296, 297):—

FIG. 296.—Large congenital cyst under the tongue. (*Stephen Paget's case.*)

Case 8.—The child at birth was nearly suffocated, and the cyst so protruded from the mouth as actually to make delivery difficult. It was tapped at once, and nearly a tumblerful of clear watery fluid was drawn off. It was tapped twenty times in the first year, as further operative procedures were refused. The child was now four years old. The cyst hung out of her mouth, almost touching the sternum, and jerked up and down with the movements of the tongue when the child swallowed and talked. It was covered with a dry cuticle as thick as the skin, the lips were everted and the jaws deformed, the front teeth looked forwards and downwards. The cyst was removed. It contained some ounces of turbid yellow fluid. The wall was simple fibrous tissue with no trace of epithelium. It was therefore not a dermoid, and the thick fluid showed that it was not a hygroma of the neck.

Butlin classes this case as a cyst of the incisive gland, but on what grounds is not stated. The incisive gland is only an inconstant collection of mucous glands.

Acute Ranula.—These are swellings which seem to be formed in connection with the submaxillary gland. They come on rapidly and without obvious reason. A swelling suddenly forms in the floor of the mouth, pushing the tongue to the opposite side and rolling it upwards and backwards, till it is almost lost to sight. The swelling is accompanied by great pain. Breathing is very difficult, and the patient may become cyanotic. The friends and onlookers are alarmed, and the patient becomes nervous and agitated, as there seems every likelihood of the swelling increasing till suffocation takes place. The cause of the condition is some sudden block to the outflow of the saliva, and may occur as the result of the blockage of the duct by a stone. All cases, however, which can be attributed to calculi have been eliminated from consideration here. Blockage, however, may occur from less obvious causes, many of which have escaped notice, but probably most are due to inspissation of mucus in the secretion.

FIG. 297.—The cyst shown in *Fig.* 296 after removal.

This is well illustrated in the case reported by Buzby :—

Case 9.—A man, age 34, while eating lunch had a sudden and violently painful swelling appear in the left submaxillary region. It was so severe that he could not continue eating, and he was slightly nauseated. He was examined within half an hour, when a greyish granular plug 2 mm. in diameter was seen protruding from Wharton's duct ; the gland was swollen and exquisitely tender. This granular material was removed, and was followed by a gush of saliva. Next day the tenderness was less, but there was a slight amount of detritus protruding from the duct.

Du Cane reported a case in which he sought diligently for a cause but could find none :—

Case 10.—A man in excellent health had just begun dinner when suddenly his mouth was filled up with a tumour which formed beneath his tongue, and increasing rapidly in size pushed his tongue backwards so that only the under surface of the tip could be seen. Two large pinkish swellings were visible in the floor of the mouth. The patient could neither speak nor swallow, had severe dyspnœa, and thought he was going to suffocate. No stenosis nor salivary calculus of the duct could be found. An incision was made, and immediate relief given on the exit of one and a half ounces of saliva. No other cysts or any signs of calculus were found, and there was no return of the symptoms.

The relation this sudden blocking bears to calculus is shown in Johnston's case, which is as follows :—

Case 11.—Mrs. C. M., complained of a sudden severe pain in the mouth and tongue. She could open her mouth only with difficulty, and could scarcely protrude her tongue. Under the tongue was a soft, rounded mass at the opening of Wharton's duct. Incision into this was followed by a gush of pus and the ejection of a semi-solid mass which proved to be a small stone surrounded by a substance resembling cooked macaroni.

Other similar cases have been reported by Bogros and in the *Dental Cosmos*, 1916 ; the *Clinical Journal*, July, 1907 ; and the *Deutsche Monatschrift für Zahnheilkunde*, 1908, 316.

Bouchard reported three curious cases. In one a woman felt her mouth suddenly filled by a tumour after drinking a glass of wine, and was soon in imminent danger of suffocation. The second was a man whose mouth filled in the same way while he was at a meal, and the third a woman in whom a tumour like the finger of a glove appeared rapidly below her tongue. In the last case, however, the same thing had occurred three times previously during eating, and all pain had passed off when eating was stopped, so that the cause, we strongly suspect, was a calculus.

Tilleaux mentions three similar cases which he ascribed to the enlargement of Fleischmann's bursa, into which he thought the duct of Wharton had burst : a worker who went to bed well but woke at 3 a.m. with the 'instantaneous formation' of a tumour under the tongue which menaced him with asphyxiation ; a cook while performing her duties, and a woman who was sitting by the fire, were all suddenly attacked in the same way. The members of the medical society before whom Tilleaux exhibited the specimen showing the bursa, said that the space was only an artefact in areolar tissue, and plainly indicated that they did not believe that such a bursa existed.

Morestin mentions an unusual case of sudden enlargement of a ranula which had been present, and small, for five years or more. The man then

contracted syphilis and was treated with large doses of mercury; he developed a stomatitis, and the swelling rapidly grew larger. It was removed.

Traumatic Ranula.—This is a swelling which results from the blocking of Wharton's duct either by a membrane or by a swelling, the result of bruising or trauma. The formation of leucoplakia may also be included here. It does not seem to be important, and an example of each will suffice. Richet notes blocking of the duct by a membrane:—

Case 12.—A young woman came with all the symptoms of ranula, and a swelling on the left side of the floor of the mouth. It was thought at first that she had osteitis of the jaw due to a bad tooth, but further examination showed that there was a dense resistant membrane on the floor of the mouth completely blocking Wharton's duct, from which no flow of saliva was visible.

French reports a traumatic case:—

Case 13.—A schoolboy, age 11, was sent to the doctor by his teacher for a 'gumboil'. One week previously, while eating a very hard apple a piece pressed on the floor of the mouth and caused him pain, and a lump appeared in a few minutes which precluded further mastication. There was a tense, cystic, transparent, irregular swelling about the size of a large walnut, below and to the right of the frænum close to Wharton's duct. The surface had small blood-vessels branching in all directions. A seton was passed, which evacuated the viscid contents.

Erichsen mentions a case where the slipping of a pair of forceps wounded the floor of the mouth in the vicinity of Wharton's duct and the saliva accumulated in the form of a cyst.

A case due to leucoplakia occurred in St. Mary's Hospital:—

Case 14.—H. R., age 50, had noticed for the last nine months a whitish patch growing under his tongue.

On admission a small patch of leucoplakia was seen in the region of the frænum on the right side. This patch was removed with scissors, and he left the hospital. Six months later he was readmitted with a history that he had had a swelling for the last four months under the tongue. A bluish white ranula was seen on the right side. It was dissected out.

Curious as it may sound, foreign bodies have found their way by accident along Wharton's duct and blocked it. In old-standing cases a deposition of lime salts has taken place upon them, causing calculi. Thus Closmadeuc reported a case where a piece of straw was found protruding from the duct. Bouillet mentions a man who was ill for nearly three weeks with pain and swelling of the tongue, in whom daily probing of Wharton's duct gave relief to the symptoms, as each time saliva was let out. At the end of this time an incision was made and a piece of straw found. There is the case of a soldier in whom a whole spikelet of corn was found in the duct, a central axis with four small leaves attached by thin pedicles, upon which lime salts had begun to be deposited.

Hulke reported a case with calculi in which the primary calculus was formed round a splinter of wood.

Delery and an Italian writer whose reference is lost both noted cases where a stone had been formed round a fish-bone; Moure and Soupault record a case where it was round the bristle of a toothbrush; Claude reported a tailor who had a pig's bristle in his duct.

LARGE BILOCULAR AND BURROWING RANULÆ.

I have classed the ranulæ which I am about to describe under the above headings, as it is difficult if not impossible to define them. Their nature is uncertain, and except their description, little is known about them. They are ranulæ which emerge from the mouth, spread to the face, the fauces, or the neck, to such an extent that the small tumour of the mouth appears negligible beside the huge tumour in the neck or face, and the extension becomes the most important, as well as the largest part of the condition. In some cases the floor of the mouth cicatrizes and no swelling forms, there being merely a small outlet to the swelling of the neck. It is only after careful study that any idea is obtained of their range, growth, relations, and extent. It appears that most of the theories as to their origin have been propounded after one or at most two curious cases have been met with, and so many theories have been suggested that one rather hesitates to give one's own view.

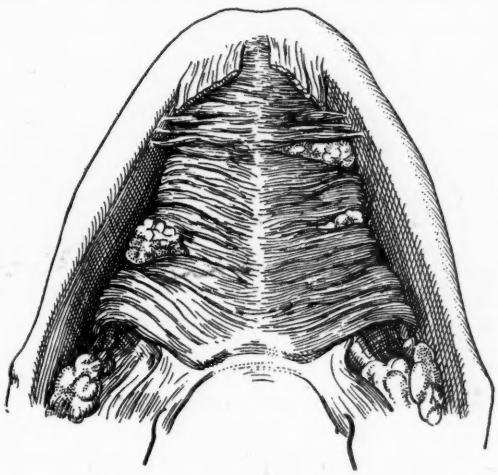


FIG. 298.—Dissection of the mylohyoid muscle showing prolongations of the sublingual gland through the muscle. Two other dissections were published illustrating the same thing (*Morestin*).

It is possible and even probable that they all start in the sublingual region as ordinary ranulæ. Some may start in the mucous glands, some in the sublingual gland, and some in the submaxillary gland. It is useless, however, to dogmatize upon this, and it is more worth while to lay the evidence in favour of this happening before the reader.

From the cases already recounted to illustrate the other features of ranula, it is obvious that a bulging below the chin may take place, though the tumour may not be below the mylohyoid muscle. In acute and congenital ranulæ, swelling of the submaxillary gland has been noted. Morestin has shown by careful dissection that the sublingual gland often protrudes naturally through the fibres of the mylohyoid muscle as a sort of hernia (*Fig.* 298). This gland too has no capsule, and is therefore in a position to be dilated. These being the facts we can trace the gradual extension of tumours which were obviously sublingual ranulæ to begin with to below the chin, into the neck, and so approach the rare and astonishing cases which have been placed upon record, where the extension has overhung the sternum.

In order to establish this gradual extension quite clearly I shall quote the following cases:—

Case 15.—A girl, 7 years old, had a small tumour under her tongue which steadily grew larger until it was the size of a nut. It was situated under the frænum, bilobed, fluctuating, with thin and transparent walls. It pushed the

tongue upwards. It was a sublingual ranula, as salt upon the tongue caused saliva to flow from Wharton's duct. The anterior wall of the cyst was removed. Six months later there was a tumour the size of a mandarin orange under the chin, with a little tumour in the mouth. There was a communication between the two. The tumour had begun to form three months after the last operation. Both tumours were dissected out.

Carp gives a similar case :—

Case 16.—A woman, age 29, who had a ranula under the tongue on the left side in January, by July had an extension into the neck. The tumour under the tongue was excised, and the swelling in the neck disappeared. Two years later there was a recurrence in the mouth, which was operated upon and was only cured for three weeks. There was now a swelling in the mouth and one in the submaxillary and cervical regions. The tumour in the neck was elastic and fluctuating, and pressure upon it caused increase in the size of the ranula. The ranula was opened, and a probe passed through its cavity into the neck for four inches ; eight ounces of fluid were evacuated. Two days later the swelling in the neck returned and was opened, and the interior was swabbed with pure phenol and packed.

Lewis reported the following clear case :—

Case 17.—A patient complained of a swelling under the tongue and also beneath the left jaw. He had been operated upon four times inside the mouth, and each time the cyst recurred. In 1919 he had a cyst the size of a goose's egg beneath the jaw. He refused a general anæsthetic, and a local anæsthetic was injected. The cyst ruptured, but as much as possible was removed, together with the sublingual and submaxillary glands. A year later there was a recurrence in the neck. This time a general anæsthetic was used and the cyst wall dissected out intact, and easily traced to the point in the mylohyoid muscle where it emerged. The muscle was slit and the whole cyst removed.

The writer states that the cyst originated in the sublingual or Fleischmann's bursa, but, as is usual, no evidence is produced why it should originate in this supposed bursa.

Boyer reported a good case illustrating the next stage of extension, which has the additional interest that the patient in her youth was operated upon by Baron Larrey, Napoleon's famous Marshal, who, he said, was worth battalions to his army :—

Case 18.—A woman, age 40, had had a congenital ranula which had been opened many times and fluid like white of egg let out. Fifteen years previously it was of considerable size, projected under the tongue, and made a salient under the chin the size of an egg. Baron Larrey operated upon it with a cautery. This operation appeared at first satisfactory, but later the tumour recurred and increased in size. Further operation was refused. She subsequently became ill with pneumonia, during which illness the tumour increased very much in size. There now existed a tumour in the form of a calabash, the upper and smaller half in the mouth nearly filling its cavity and rolling the tongue backwards against the palate. The other half was below the chin, the size of two fists, and descended vertically in front of the neck. There was a deep groove between the posterior margin of the tumour and the front of the larynx. It swelled out below the level of the jaws and drew strongly on the skin of the chin and the cheeks, rendering it excessively tense. The surface of the tumour was red, tender, hard, and inflamed, and the patient could scarcely open her mouth. The face was cyanotic, and swallowing and speaking were difficult ; there was fever. The tumour was punctured twice, and a flocculus of pus squirted out about a yard by its own pressure. A seton was passed, and half a litre of pus came away. The tongue returned to its place and the symptoms were relieved. After washing out the cavity for some days, only fistulous openings remained.

These cases sometimes gave rise to alarming symptoms, which are illustrated in the case reported by Wheeler :—

Case 19.—The patient suffered from a large ranula complicated by a tumour beneath the jaw. The usual signs of ranula were present, better marked than in the generality of cases. The tumour beneath the jaw was the size of a Seville (bitter) orange. She had known of the ranula for about a year, but was unaware when the tumour appeared beneath the jaw. The two tumours were thought to be distinct from one another. The appearance of the latter tumour gave one the impression that there was a calculus in Wharton's duct. A piece of the cyst beneath the tongue was excised, and glairy fluid came out, and later some dark fluid. Pressure beneath the jaw caused a further flow and emptied the tumour. Notwithstanding that a 'large piece of bone' was removed from the ranula, the swellings reappeared.

One day she was in her usual health, but by the evening she was suffering intense dyspnœa, her eyes were starting from her head, the countenance was anxious and distressed, and she was in a cold perspiration, sitting up grasping the bedclothes like one with asthma. Both tumours had increased greatly. An incision was made into the dorsum of the tongue on each side near the raphé. As not much relief was obtained, incisions were made into the two swellings, and fluid escaped from both and relief followed. The epiglottis could now be felt, and as it was swollen it was scored with a knife. Poultices and fomentations were applied and the patient managed to swallow half a teaspoonful of milk. Next day the tumour beneath the jaw was opened and its cheesy contents were removed. Complete healing followed.

In this case, if the 'piece of bone' removed was really a calculus as it had been suspected, then it merely proves that an ordinary obstructive ranula may form a large cyst beneath the jaw. The 'cheesy' consistence of the contents might mean that this case should not be included here but was really a dermoid. In Malcolmson's case, however, the contents were not only cheesy but solid in parts, though derived from the submaxillary gland. Tay also removed five masses like hard butter from a ranula, and Leclerc let out glairy fluid and sandy material.

The recovery was probably due to the inflammation, which cured many such cases and also brought about a cure in the astonishing instance related below. This was reported by Paget, and will carry the conviction which is borne by all that great observer's writings. It illustrates the extension taking place in an upward direction into the face :—

Case 20.—A man, age 34, had a cyst over the right side of the face and neck. It was half filled with fluid, irregular, lobulated, subcutaneous, and extended from the level of the cricoid up over the jaw to the malar bone and the zygoma, back to the masseter muscle and the posterior border of the lower jaw, and as far forwards as the middle line beneath the chin, and to the angle of the mouth. It was described as being " soft, flaccid, fluctuating, and flapping ". On pressure " a little glairy, fluid oozed through a small aperture in the middle line in front of the frænum linguæ ". The floor of the mouth was slightly raised and harder than normal. This swelling had existed for four years. It had commenced as a swelling under the tongue, which after a year burst, discharged glairy fluid, and disappeared. There was no further swelling under the tongue. Next there appeared a swelling under the jaw, and this burst as before under the tongue and disappeared. This swelling appeared again under the jaw and gradually spread out on to the cheek, without pain. It was punctured, and twelve ounces of glairy fluid were drawn off, tinged with pink. It was punctured again later, and then suppurated, and so was cured in two months' time.

In this case there can be no question but that the tumour began under the tongue and eventually extended to the limits indicated. Other cases are mentioned by Després, Bellonard, and Dieu. The climax, however, is reached in the case reported by Malcolmson :—

Case 21.—A sickly Hindoo boy of 9 came on account of a swelling which extended from one ear to the other, up over the angles of the jaw, up on to the cheeks, and down to the sternum, over the upper end of which bone it was pendulous and could be lifted up. It was quite soft and contained fluid. The disease had started a year previously. Before the tumour was noticed, a discharge of pus had been seen half an inch to one side of the opening of the left submaxillary duct. There was a depressed cicatrix at this point, and the swelling was said to have started here. A slight discharge could still be seen from the duct. From these facts it was thought that the duct had inflamed in consequence of septic teeth, and the saliva had found its way out into the connective tissues and formed the great swelling described above. A puncture was made into the swelling, and twenty ounces of glairy fluid, transparent and of a light-brown hue, were withdrawn. A hard mobile substance was then felt and was extracted on enlarging the opening. It proved to be part of the fluid which had become inspissated. The opening was left and the discharge pressed out every morning. The puncture then closed and another had to be made. After this the skin of the cheeks seemed to unite with the underlying muscles from which it had been separated, so that in this area healing was obtained.

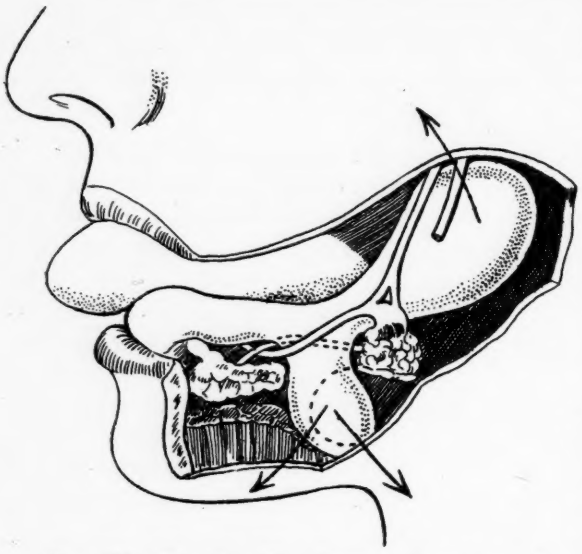


FIG. 299.—*Case* 22. The diagram shows a ranula under the tongue. The arrows indicate its extension through the mylohyoid muscle to below the chin, to the neck and face, and to the fauces.

The patient was then lost sight of for some weeks and the puncture closed. He was seen again, and another puncture was made and much fluid drawn off; suppuration took place and pus followed for some time. A probe passed into the mouth of the duct caused saliva to flow. A portion of the skin of the tumour was removed and the tissues were laid bare; it was as if a dissection was made of the neck; everything from the ears to the sternum was exposed, with the blue veins and parotid glands showing through. A search was then made for the origin of the fluid, and it was traced to a soft round body like a small lymphatic gland which proved to be part of the submaxillary gland, pressure upon which caused the glairy fluid to exude. The submaxillary gland was removed, and the cautery applied to the stump. The wound healed up at once, and nothing more was discharged into the mouth.

The next case (*Fig.* 299) is an illustration of extension which sometimes may take place inside the mouth into the fauces and pharynx :—

Case 22.—A woman of 34, who had a left-sided ranula under the tongue which was repeatedly opened and fluid like the white of an egg let out. Digital examination showed that there was an extension backwards under the mucous membrane

into the parafaucial region as well as an extension into the submaxillary region. She also had a typical sublingual ranula on the right side, which was quite distinct and which was removed, the opposite side being left severely alone. (Blair.)

CONCLUSIONS.

From a consideration of such cases, which fairly represent every form of tumour described, we can only come to the conclusion already laid down that these tumours form first in the mouth, and then spread, extend, or burrow into the other regions. Many are in connection with the submaxillary gland, others are not so obviously in connection with this gland, and others again have no connection with it. When traced to the region of the sublingual gland we have no means of telling whether they are mucous or salivary in origin. Birkett mentions one in which a probe could be passed along Wharton's duct, though there was a ranula with an extension into the neck.

Fleischmann described his bursa in 1841. but no one has been able to confirm his findings. The efforts of Tilleaux to establish the bursa were not accepted by his hearers. Skillern reported a bilocular ranula which he said originated in the bursa, but no proofs were forthcoming. The white-of-egg fluid was different perhaps from saliva, but it was not analysed, and seems to have differed very little from the fluid found in those cases which were obviously in connection with the submaxillary gland. I am not aware if the fluid from any of these extensive cases has been analysed, or if it differs, as well it might, from normal saliva. We know that saliva from the submaxillary gland differs from that of the parotid, and in physiological text-books it is said that saliva from the sublingual is intermediate between the two; but I am unaware that it has ever been collected in man. Skillern says that Leopold Gmelin proved that the fluid from a ranula has no similarity to saliva, but the reference he gives is wrong (Wochlors u. Liebigs *Annalen der Chemie u. Pharmacie*, lxxiv, 95). (The only reference to this writer I can find is in the volume published in 1835, i, 95, which refers to the analysis of a 'lung stone.')

Lewis, seeing Skillern's case, reported a similar one, and attributed it also to this bursa, but neither does he give reasons for so doing. Careful search by anatomists has always failed to find this bursa. Artificial spaces are easily made in the loose tissues between the geniohyoglossus muscles, and to this fact we must attribute the description of the bursa. Another theory as to their origin has been put forward by Thompson: that these ranulæ start from the cervical sinus left by the development of the branchial clefts. "Wharton's duct and the sublingual gland can be seen superficial to the cyst, but not structurally connected with it"; and again: "I have satisfied myself in every case of ranula that has come under my observation that neither Wharton's duct nor the sublingual gland are responsible by finding that these structures were healthy and normally placed".

I might accept the reference to the submaxillary gland if it had not already been proved that the submaxillary gland has been in direct communication with these extensions, as in Malcolmson's case; but with regard to the sublingual gland this statement cannot be allowed to pass. It is difficult if not impossible to make out the sublingual gland in connection with a ranula,

and it is because of this uncertainty that our ideas upon the subject are so untrustworthy. Secondly, how can one prove that the sublingual glands are healthy or normal? Can anyone pass a bristle into them? I have never been able to do so. Does anyone know how many ducts are present in each gland? According to Suzanne's dissections the ducts differ remarkably in number and pattern. If one is blocked, how are we to know, for now we cannot pass in even the bristle, and therefore we cannot know that a duct should be there? I cannot help thinking that Thompson has eliminated the sublingual gland because it is in the way of his theory. He owns the possibility of the mucous glands. But why not then accept Fleischmann's bursa as the remnant of the cervical sinus? Well, that is perhaps obvious—no one can find it. There is one insuperable obstacle against accepting the theory of the cervical sinus, and that is the lack of an epithelial lining to the cyst walls. No one has described any epithelial lining with the sole exception of Lewis, and he attributes the swelling to Fleischmann's bursa, in which there should be no epithelial lining. One wonders therefore if Lewis did not really mean endothelial and not epithelial lining. The lining of the swelling in the mouth is always mucous membrane or glandular when examined; once the swelling has burst and gained the connective tissue, the lining will be endothelial. It is just this lack of any epithelial lining which makes these cysts so easily cured once they suppurate or become inflamed.

Thompson also says: "I have made a somewhat exhaustive search of reported cases, but so far I have been unable to find cases that correspond anatomically to these reported above", referring to the two he published. His cases were of the ordinary bilocular type already quoted, with not very large extensions into the neck. No exhaustive study of the cases has been made in this paper, but from those cases included, which are only a selection, one can gather that they are not as rare as he supposes. I might suggest also that some of the rare cysts which have been described in the neck may be related to this condition. It is not from the study of two examples that a true picture can be drawn: the whole range of cases must be considered, and it is for this reason that this paper has been unduly laden with case reports.

The conclusions drawn are that a ranula may arise in the salivary glands, including Blandin's gland, and in the mucous glands, and nowhere else. There is nothing to favour the view that Fleischmann's bursa exists, and there is nothing to connect a ranula with the supposed survival of a cervical sinus.

BIBLIOGRAPHY.

BAKER, *St. Bart's Hosp. Rep.*, 1871, vii, 134.
BELLONARD, *L'Union méd.*, 1875, 799.
BLAIR, *Ann. of Surg.*, 1923, lxxvii, 681.
BLOT, *Bull. Soc. de Chir.*, 1870, xi, 179.
BOGROS, *Gaz. des Hôp.*, 1850, 307.
BOUCHARD, *Bull. Soc. de Chir.*, 1869, x, 445.
BOYER, *L'Union méd.*, 1848, ii, 22.
CARP, *Surg. Gynecol. and Obst.*, 1921, xxxi, 182.
COOKE, WEEDEN, *Lancet*, 1859, ii, 186.
CURTIS, *Ann. of Surg.*, 1898, xxvii 662.

DELENS, *Bull. Soc. de Chir.*, 1881, vii, 462.
DESCHAMPS, *Gaz. méd. de Paris*, 1860, xv, 552.
DESPRÉS, *Gaz. des Hôp.*, 1896, 549.
DIEU, *Bull. et Mém. Soc. de Chir.*, 1881, vii, 456.
DU CANE, *Lancet*, 1890, i, 463.
EVE, *Trans. Pathol. Soc.*, 1889, xxxix, 101.
FODERL, *Arch. f. klin. Chir.*, xlix, 531.
FRENCH, *Med. Record*, 1888, 507.
GIRALDÈS, mentioned by BLOT.
GUÉNIOT, mentioned by BLOT.
GUINARD, *Gaz. hebd. de Méd. et de Chir.*, 1888.
GUYON, *Bull. Soc. de Chir.*, 1886, 145.
LANNELOGUE, *Kystes congenitaux*, Paris.
LECLERC, mentioned by MALCOLMSON.
LEWIS, *Surg. Gynecol. and Obst.*, 1920, 82.
LOCKWOOD, *Med. Times*, 1882, i, 329.
LOMBARD, quoted by BELLONARD.
MALCOLMSON, *Calcutta Med. and Physical Trans.*, viii, 13.
MORESTIN, *Gaz. des Hôp.*, 1897, lxx, 529; *Bull. Soc. Anat.*, 1897, 307, and 1902, xlix, 711.
MULLER, quoted by GUINARD.
PAGET, SIR JAMES, *Study of Old Case Books*, 1891, 152.
PAGET, STEPHEN, *Trans. Pathol. Soc.*, 1892, xliii, 57.
PANAS, *Bull. et Mém. Soc. de Chir.*, vi, 60.
RAMON TEJADA AGUIRRE, *Surg. Gynecol. and Obst.*, 1918, 45.
RICHER, *Grenomelette congenitale*, Paris, 1883.
RICHET, *L'Union méd.*, 1880, 716.
SKILLERN, *Surg. Gynecol. and Obst.*, 1919, xxix, 447.
STOLTZ, *Gaz. méd. de Paris*, 1833, 763.
TAY, *Trans. Pathol. Soc.*, 1871, xxii, 258.
THOMPSON, *Ann. of Surg.*, 1920, lxxii, 164.
TILLEAUX, *L'Union méd.*, 1874, 957.
VON RECKLINGHAUSEN, *Virchow's Arch.*, 1881, lxxxiv, 425.
WHEELER, *Med. Press and Circ.*, 1880, xxix., 188.

SOME CONTRIBUTIONS TO THE RECONSTRUCTIVE SURGERY OF THE HIP.

By ERNEST W. HEY GROVES, Bristol.

(Being the Bradshaw Lecture delivered before the Royal College of Surgeons, England, on November 11, 1926.)

Of all the joints in the body the hip is perhaps the most important, and in regard to its ailments is certainly the most difficult for treatment.

Whilst our remote ancestors were quadrupeds who bore the body weight on four limbs, our nearer progenitors were tree-climbers or jungle-dwellers and still used the forelimbs almost as much as the hind for progression. The human being now has to do all his weight-carrying on two limbs only, except during a brief period of infancy, when he begins his life with his ancestral crawl. This evolution from quadruped to anthropoid and anthropoid to human mode of progression has involved a big strain on the hip, for it has to carry double the weight and also provide for a balancing of the erect body. It is the only joint which is commonly affected by congenital dislocation, and its liability to spontaneous or pathological dislocation is far greater than that of any other joint. The two most important diseases of joints—namely, tubercle and osteo-arthritis—attack the hip more frequently than any other single joint, and the result of such attack is more serious and more difficult of treatment.

Anatomically, too, the hip presents important characters of its own. The large epiphysis of the head is entirely intra-articular and possesses a very poor blood-supply apart from the vessels which enter it from the diaphysis. The angle which the neck of the femur makes with the shaft, perfectly adapted for conditions of health, is very liable to distortion by disease or trauma, and this distortion at once destroys the correct balance of the trunk on the lower limb.

To replace and retain the dislocated hip; to re-establish correct relations between an ill-formed femoral head and an ill-developed acetabulum, and to attach a displaced epiphysis or to mend the broken neck of the femur, keeping it at the correct angle with the shaft of the bone; to remake the joint when it has been destroyed by inflammation; and to replace by active structures the paralysed muscles required for balancing the body in the erect position—these are the problems which constitute the reconstructive surgery of the hip.

Considerations of time and space prevent me from dealing either with the history or the literature of this subject, and I propose therefore to confine myself almost entirely to my personal experiences.

FRACTURE OF THE NECK OF THE FEMUR.

The true neck of the femur lies proximal to the intertrochanteric line, and it is only about the fractures of this region that we are concerned. This is the intracapsular fracture of the older writers, but it is better described

to-day under the terms subcapital or basal, according to whether the line of fracture is near to the head or the base of the neck. The extracapsular or pertrochanteric fracture involves the trochanters, and in its mode of healing and reaction to treatment exactly resembles fractures of the other parts of the diaphysis—that is, it forms abundant callus and undergoes rapid and firm union which is very liable to deformity unless efficiently treated by traction and splints.

FIG. 300.—Fracture of the neck of the femur, twenty-five years after the causal accident.

Causes of Non-union.—Fracture of the true neck of the femur is notable for the fact that it never unites naturally—that is, if the patient merely lies in bed with the leg in line with the body. This tendency to non-union used to be attributed to old age, but this certainly is not correct, because the fracture unites quite well in old people if properly treated, and is just as obstinate with regard to non-union in a young man as in an old one if special treatment is not adopted. I would place the causes of non-union in the following order of importance: (1) Defective blood-supply; (2) Defective apposition of the fragments; (3) Interposition of the capsule; and (4) The inhibitive influence of the synovial fluid.

About the fact and the effect of the defective blood-supply there can be no doubt. The head of the bone gets a very feeble and inconstant supply through the round ligament, and its main nutriment through the vessels which run up the neck, which latter are all torn by the injury. It is untrue to say that the separated head is dead, because—whether by the vessels of the ligamentum teres or by the synovial nourishment of the cartilage—the fragment certainly retains living cells and is capable of resuming active life for a long time (*Figs.* 300, 301). It would be fair to say that the head of the femur so long as it is separated from the shaft is in a condition of suspended animation. However quickly or efficiently the fracture is treated, there is never any callus excess; in fact, it would be difficult to demonstrate callus formation in any case at all. It is a region where neither periosteum nor endosteum exists, so bone granulation tissue or

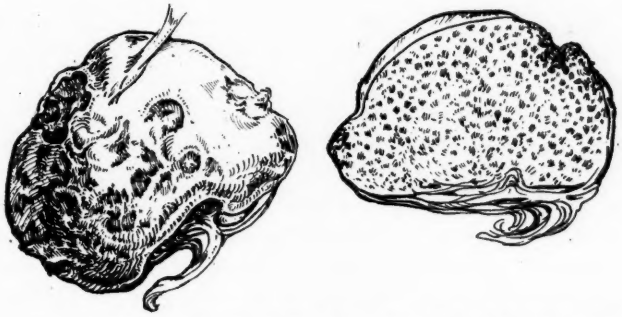


FIG. 301.—The same case as *Fig.* 300. Head of the femur shown after removal; the structure proves that vitality has been retained.

callus cannot be expected. This means that there is no provision for filling up interstices or bridging gaps such as exists in those fractures of the shaft where apposition is not perfect. On the other hand, if the fragments are firmly and accurately apposed, bony union will take place with certainty. This explains the most characteristic feature of these fractures—that is to say, that they will never unite unless perfect apposition of the broken surfaces is secured; but if this is done, firm bony union occurs. Another evidence of the influence of defective blood-supply is seen in the rapid atrophy of the proximal fragment which occurs if correct treatment is delayed. Within three to six months of the injury all that part of the neck of the femur which is attached to the head disappears. This is a point of great practical importance because it means that if efficient treatment is delayed perfect reconstruction of the neck can never take place.

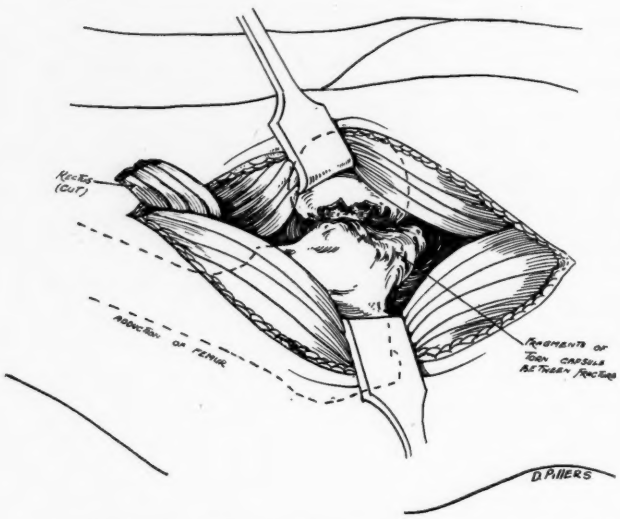


FIG. 302.—Drawing of exposure of a fractured neck of the femur. The reflection of the torn capsule over the distal fragment is well seen.

These, then, are the main causes of non-union—namely, defective blood-supply and a want of apposition—but the other two causes mentioned above have to be considered. In many cases the reflected portion of the capsule of the joint hangs over the torn end, usually of the distal fragment, and thus interposes a fascial membrane between the broken bone surfaces (*Fig.* 302). This interposition may not be so complete as to prevent union if by manipulation the bone surfaces are impacted one against the other, but it must tend to delay union, and sometimes actually prevents bony union.

The effect of the synovial fluid which bathes the broken surfaces of the fracture is more problematical than that of the factors already mentioned, but it cannot be ignored. The effect of the synovia is to deposit a fibrous surface on the raw bone and so to seal up its cellular elements. Thus, after a few weeks both surfaces will be covered with this fibrous tissue which will make the bony union more difficult even if by manipulation the bone is impacted. There is, then, a quite adequate explanation of why these fractures will not unite if left to nature. Immediately after the accident the broken surfaces fall apart, the distal fragment being pulled upwards by the contraction of the muscles and falling outwards by the weight of the leg producing external rotation. There is no capacity for callus production to bridge the gap, whilst the torn reflected fibres of the capsule hang over the broken surface of the distal fragment. In a few weeks both broken surfaces become covered with fibrous tissue, and in a few months the proximal fragment has greatly atrophied.

Treatment of Recent Fractures.—These considerations at once give the three essential points in treatment—namely, early intervention, accurate apposition, and firm fixation. Whilst these principles are universally accepted by all specialists and by the majority of surgeons, yet, unfortunately, they are not acted upon by a great many in general practice. The very existence of the fracture is often overlooked, owing to the fact that the injury is usually one resulting from comparatively trivial violence such as falling on the pavement. Then, when after several weeks the X rays are applied and the fracture is seen, there is a tendency either to minimize its severity and to temporize with bed and sandbags or a Liston's long splint, or, on the other hand, to regard the fracture as unamenable to treatment and to let the patient get up with crutches as soon as he likes. It is only perhaps after six months or more that the pain or the lameness calls for another opinion, and then the time has gone by when a perfect cure can be effected.

Abduction in Plaster.—Although the fracture presents such varied obstacles to natural union, it is not difficult to obtain apposition of the bone surfaces by manipulation. Under an anæsthetic traction is made upon the leg until it is the same length as its fellow, and then, without releasing the traction, the limb is first inverted and then brought up into extreme abduction with a little flexion. This manœuvre can be done under the observation of the X rays or when the parts are exposed by an open operation, and it will be observed how the internal rotation and abduction do force the broken surfaces of the neck together. But two further points are noticed: (1) That the proximal fragment may remain out of place, usually looking forwards or upwards, and that no movement of the limb can correct this; and (2) That frequently a part of the capsule of the joint lies like a veil over the distal fracture surface. When the triple manipulation of traction, internal rotation, and abduction has been accomplished, the limb is fixed with plaster-of-Paris extending from the lower part of the chest to the toes, and so it remains for about three to six months with one or more changes of plaster case.

Whitman, who has fully established the efficiency of this method both in theory and practice, seems to think it should be the routine procedure for all cases. His advocacy has been sufficient to convince most surgeons, and it may be said that to-day abduction followed by plaster is the standard mode of treatment. Although this method is a very great advance over either traction or simple splinting, and has proved that even in old people fractures of the neck can be made to heal by bony union, yet in my opinion it is by no means ideal or convenient. In the first place it is liable to failure, and this failure is recognized only after the long tedium of confinement in a plaster case has been endured. That failure does occur frequently is shown, for example, by such figures as those of Waldenström,[1] who in 43 cases reports failure to produce bony union in 22. The explanation of the failure lies in the two facts already mentioned—namely, that the upper fragment cannot be controlled and often lies with its broken surface pointing forwards, and that part of the capsule interposes between the broken surfaces. The method is not easy to carry out unless hospital accommodation allows the patient to be kept in for three to six months. Even then the retention of the abdomen and leg in plaster for such a long period is open to the objection that thin

patients may be rubbed sore, or that fat patients cannot be efficiently fixed. Moreover, even if all these difficulties are surmounted, the method still imposes a great strain on patient and nurse.

THE PEGGING OPERATION.—As far as I am aware, no one surgeon is especially to be credited with the idea of fixing the broken femoral neck by means of a bone or ivory peg. The method was gradually evolved from that of using a long carpenter's screw. This screw, which is still used by many surgeons, is open to the objection that it gets no good hold in the soft cancellous tissue of the neck and head of the bone, and it does not become incorporated in the skeletal structures. The substitution of a peg for a screw was suggested by the better mechanical hold given to the former, and by the idea that a bone-peg would become a part of the new bone. There still remain differences of opinion whether the peg should be made of a living graft taken from the patient's own skeleton or of a piece of animal bone or ivory; also whether it should be driven in blindly or under the guidance of an open operation. I propose to describe the operation as I think it should be done in most cases, and will then refer to possible modifications in respect to these details.

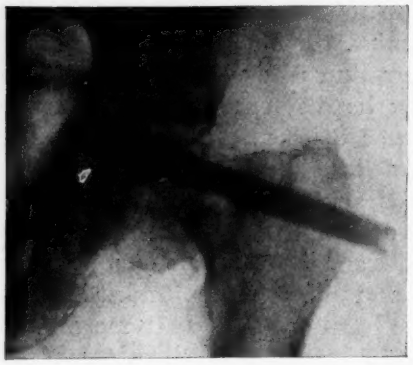


FIG. 303.—Peg driven too far.

A bone peg is provided about 4½ in. long and ⅜ in. thick, pointed at one end and square in section. A metal handle to the peg is convenient, though not necessary, for driving it into place. A very accurate estimate should be made from the X-ray plate as to the exact length to which the peg has to be driven into the bone, and this length should be marked by providing a collar or head to the peg which will rest against the outer surface of the femur when the peg has been driven in to the correct extent. If this detail is not attended to, there is a liability for the peg to be driven in too far (*Fig.* 303) and so enter the joint, or else for it not to be driven in far enough and so not attain its maximum efficiency (*Fig.* 304). Both these errors have happened in my practice, and though they have not resulted in any serious consequences, it is clearly better to avoid them.

FIG. 304.—Peg not driven far enough.

The patient lies on the table with the affected hip over the edge. The joint is exposed by an anterior incision about 6 to 8 in. long, the centre of which is at the anterior superior iliac spine, the upper half of the incision running along the crest of the ilium and the lower half along the line of the sartorius. The incision is deepened, the fascia divided, and the muscles are

separated from the crest and outer surfaces of the ilium, the tensor fasciæ femoris being separated from the sartorius. By this means the anterior inferior spine is exposed with the origin of the rectus femoris muscle. The latter is divided and the front and outer surfaces of the hip-joint are exposed. The capsule is divided by an incision parallel to the direction of the neck of the femur, and this lays bare the fractured surfaces (*Fig.* 302). Torn and reflected parts of the capsule which lie over the distal fragment are retracted; the head of the bone is difficult to control because only so small a part of the neck is exposed, but it can be rotated into correct position and there held by stabbing a drill into it right through the edge of the cotyloid ligament.

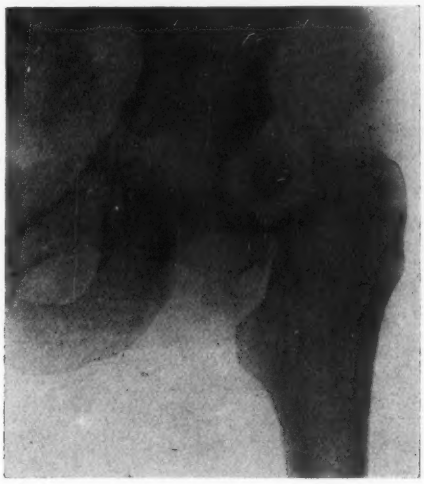


FIG. 305.—Fractured neck of the femur in a man of 35.

The outer surface of the great trochanter is now approached either by turning the original skin-flap outwards or by making a vertical incision outwards from the middle of the first incision. This enables one to expose the outer surface of the great trochanter covered by the upper fibres of the vastus externus, and is much more satisfactory than getting at the point for insertion of the peg through a separate stab incision. The depression just below the great trochanter is identified, and a hole made up into the neck with twist-drills, beginning with $\frac{1}{4}$ in. and increasing up to a drill of the same diameter as the peg to be used. The point of the drill is in the first place made to emerge at the centre of the femoral neck, the leg being externally rotated so as to throw the broken surface forward. Then the leg is so manipulated by traction, abduction, and internal rotation as to bring about as perfect restitution as possible, the head being in the meantime fixed by the transfixing awl. The drills are then made to penetrate the head of the bone to the correct depth so that a path for the peg is prepared. The square peg is driven into the round hole, into which it fits very tightly (*Figs.* 305–308). It is most important to see that it goes in far enough, but not too far. The part of the peg which projects is cut away. The capsule is carefully sewn together

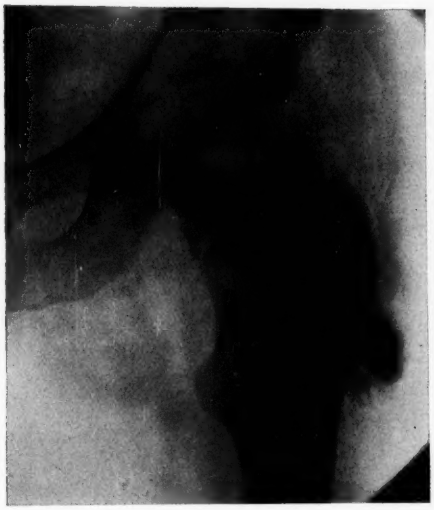


FIG. 306.—The 'same case as *Fig.* 305. The man returned to work four months after the accident.

and then a few points of suture serve to re-attach the divided muscles, and the skin is joined by clips.

After the operation the limb is slung to an overhead beam or on a cradle splint so that the knee and hip are semiflexed and the whole leg is kept in moderate abduction. A weight traction of about 10 lb. serves to steady the limb. After ten days when the wound is healed and the stitches are out the pelvis and thigh may be encased in a light plaster spica, or else the position of flexion and abduction may be maintained by weight traction, the leg being slung. I would only use the plaster for cases that have to be moved to a distance; if the patient can be kept under the observation of the surgeon and the care of a competent nurse, plaster fixation is quite unnecessary. At the end of four to six weeks the patient is allowed to walk with crutches and a caliper splint. In three to six months' time he walks without any splint at all.

FIG. 307.—Fractured neck of femur in a woman of 60.

The Slipped Epiphysis.—The displacement of the epiphysis of the head of the femur is a very remarkable injury both in its origin and its results. It is brought about by comparatively trifling violence, and the accident which produces it is often hardly remembered. The patient is not aware of any serious disability at the time, but becomes progressively lamer. If the case is seen at an early stage—that is, within a few weeks of its occurrence—the reduction by manipulation can be effected. Arguing on the same lines as above, I would say that this reduction had much better be done under the guidance of an open operation, and, when done, fixed by a bone nail (*Figs.* 309, 310). When the injury is only recognized at a later date, after union in a faulty position has occurred, it will be necessary to cut through this faulty union and perhaps remould the neck of the bone before nailing it together. It is certainly much better to do this than to wait for the establishment of a coxa vara (*Fig.* 311).

FIG. 308.—The same case as *Fig.* 307 after pegging: perfect recovery.

MODIFICATIONS IN THE PEGGING OPERATION.—

1. *Peg Inserted from Above.*—When the fracture is very close to the anatomical neck of the femur it is difficult to expose the upper fragment or to see exactly how it lies, and it needs great accuracy to put the peg exactly to the correct

depth. In such cases it is better to nail the head on to the shaft, instead of nailing the shaft to the head. When the joint has been opened the cotyloid ligament is cut through and two angular flaps of capsule are formed

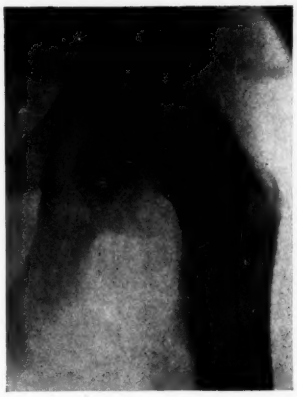


FIG. 309.—Hip from boy of 18, showing a slipped epiphysis.

FIG. 310.—The same case as *Fig.* 309 seven months after pegging, showing the almost complete absorption of the peg.

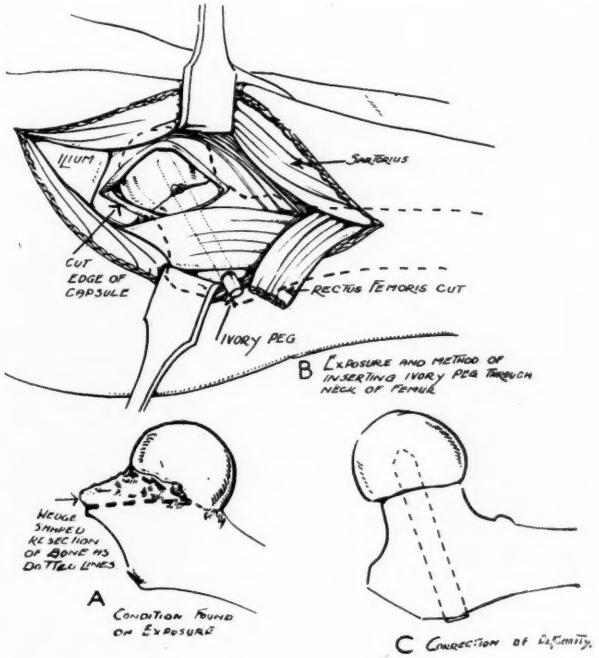

ILIUM
SARTORIUS
CUT EDGE OF CAPSULE
RECTUS FEMORIS CUT
IVORY PEG
B EXPOSURE AND METHOD OF INSERTING IVORY PEG THROUGH NECK OF FEMUR
WEDGE SHAPED RESECTION OF BONE AS DOTTED LINES
A CONDITION FOUND ON EXPOSURE
C CORRECTION OF DEFORMITY

FIG. 311.—Hip of a girl of 12, eight weeks after the epiphysis had slipped. A, Resulting deformity; B, The operation; C, Head and neck after reconstruction.

by the addition of a cross cut through the capsule at the edge of the bony lip of the acetabulum (*Fig.* 312). These flaps of capsule are held aside by strong tissue forceps, and then by means of a curved retractor the head is dislocated without division of the round ligament. This allows of a

perfect adjustment of the head to the neck, and, after drilling, the former is fixed to the latter by a bone nail 3 in. long and $\frac{3}{8}$ in. thick, having a very small flange at the head. This modification of the operation is particularly

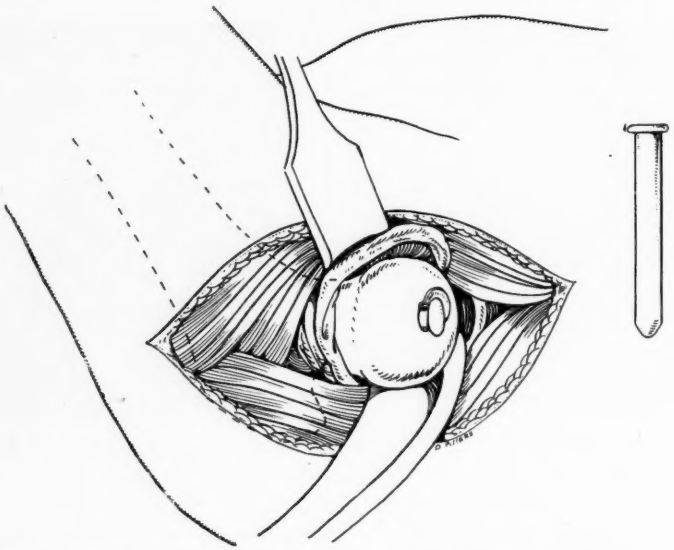


FIG. 312.—Fractured neck of the femur in a woman of 65 with very short proximal fragment. Diagram of the operation, showing the peg being inserted from above.

indicated in old-standing cases when the proximal fragment is small and the neck atrophied. It gives a greatly increased mechanical efficiency in holding the head in place (*Figs.* 313, 314).

FIG. 313.—Skiagram of the same case as *Fig.* 312 before operation.

FIG. 314.—The same case as *Fig.* 313 six weeks after operation.

2. *The Use of an Autogenous Peg.*—In my earlier cases I always used an autogenous peg cut from the crest of the tibia; but in recent fractures just as firm and rapid union has been achieved by the use of a dead-bone nail, and there are two distinct advantages in the use of the latter: (*a*) The operation is simplified and shortened; and (*b*) The peg can be prepared beforehand with greater precision than can be applied in the use of a peg cut at the time. I

have had one case, too, where a fracture occurred in the tibia after the patient began to walk, and though this healed quickly, yet it was rather a tragedy. It is possible that the use of a part of the shaft of the fibula as a peg is better than that of a graft taken from the tibial crest, but I think it is an unnecessary complication in most instances, and it should be reserved for old cases of non-union where the difference between a living- and dead-bone peg may justify the extra operation. Henderson[2] has used this method, and his cases show excellent results.

3. *The Blind Insertion of a Peg.*—There are certain obvious advantages in the insertion of a peg through a small external incision without exposing the joint. It is an easy and a simple operation, but it is liable to grave drawbacks. In the first place it is very difficult to make certain that the peg is going exactly in the right direction; *Fig.* 315, for example, shows a case where the peg has altogether missed the neck of the bone. In the second place it does not give opportunity of exact reposition of the fracture, especially in regard to correct orientation of the head; neither does it allow the removal of the interposing flap of the torn capsule. With certain precautions, however, it may still be a useful modification of the operation in some cases. The correct direction and depth of the peg can be assured to some extent by the observation of the bony landmarks of the pelvis, and by a preliminary measurement of the bone and preparation of the peg with an outstanding head or collar which should be a guide to the correct depth. The leg is pulled down, abducted, and inverted. When the depression below the outer surface of the trochanter has been identified through an external incision, the drill is inserted so as to point to the anterior superior iliac spine of the opposite side. But in addition to these precautions, I think that the operation should be done under the guidance of the fluorescent screen. I would reserve this modified operation for the cases in which age or debility makes it unwise to carry out a more extensive procedure.

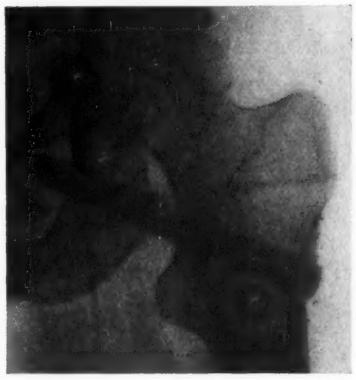


FIG. 315.—Peg inserted 'blindly'. It has missed the neck of the femur. Case seen for the first time one year after operation.

In my own experience the results of the pegging operation have been so uniformly good that I should regard it as one of the most satisfactory operations in bone surgery. If it is done early, before atrophic changes have occurred, bony union is assured and the patient will regain full functional recovery within six months of the injury.

Slowness of union and length of the period of recovery will be in proportion to the delay that has occurred between the accident and the operation. It is very important to lay stress on this point, because if my view is correct, then the operation ought to be carried out as soon after the injury as possible and not left as a last resort for those cases in which plaster abduction has failed.

The Treatment of Long-standing Non-union.—This is a very much more difficult problem. The cases may be divided into three categories: (1) Those in which delay in efficient treatment or failure of treatment has caused non-union, without much atrophy or displacement. (2) Those in which the neck of the femur has been absorbed, without much displacement. (3) Those with absorption of the neck and great upward displacement of the femoral shaft.

1. In the first group I think that the pegging operation should certainly be done. The only modification of detail necessary will be thorough exposure of the fractured surfaces with removal of old fibrous tissue, and the use of a portion of the shaft of the fibula as the peg, in order to increase the sources from which new bone may be derived. This can be relied upon to bring about firm union and a useful limb which the patient can use without pain. I have sometimes found, however, that though union is firm and painless, yet there is great limitation of movement in the hip-joint. This is probably due to the fact that the nutrition of the head of the bone has been impaired and its cartilage lost, so that it eventually becomes fixed in its socket.

2. In the second group, where the neck of the bone has been absorbed, the choice of procedure will lie between removal of the head altogether and a fixation of the head to the shaft, but in either case the upper end of the femur will have to be reconstructed so as to ensure a bearing between the femur and the acetabulum. The necessity or advisability for any operation will be determined by the amount of pain which the patient suffers. If this is so great that it makes him bedridden or dependent on crutches or a caliper splint, then it is certainly worth while to do something, for, though the operation may leave him with a weak or lame leg, it will undoubtedly relieve him from pain. The simplest procedure is certainly that devised and advocated by Whitman (*Fig.* 316). It consists in first removing the head of the bone and then cutting off the great trochanter so as to allow the stump of the neck of the femur to engage in the acetabulum. The trochanter is then attached to the shaft of the femur at a lower level. This operation will only succeed if there is sufficient neck left to form a new head in the acetabulum. If the neck has quite gone, it is difficult to prevent the shaft of the femur from riding up on to the dorsum ilii as soon as abduction is discontinued. To overcome this difficulty I have utilized the head of the bone in order to make an exaggerated rim to the acetabulum (*Fig.* 317). The head of the bone, having been removed, is cut into two parts and these are shaped so as to make a curved mass of the approximate shape of the hip socket. The upper margin of the acetabulum is then bared and a raw surface of fresh bone prepared. To this the pieces

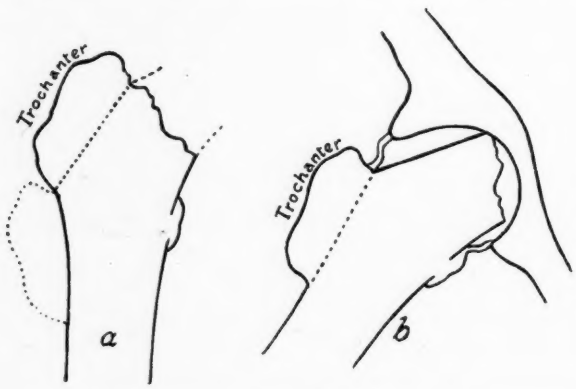


FIG. 316.—Diagram of Whitman's operation.

of femoral head are fixed by nails. The trochanter is transplanted to the outer surface of the shaft, and the raw surface at the top of the femur

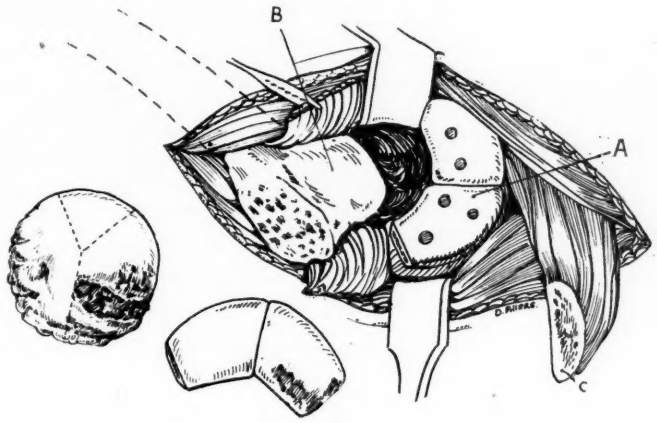


FIG. 317.—New rim made to acetabulum from the head of the femur. A, Portions of the head nailed to the edge of the hip socket; B. Neck of the femur after removal of the head; C, Great trochanter sawn off. The small figures show the head of the femur and the methods of cutting to shape.

which is to rest against the reconstructed acetabulum is covered by sewing over it the capsule of the joint (*Figs.* 318, 319). Wherever it is possible,

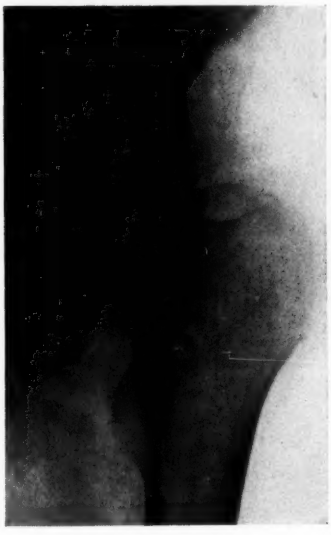


FIG. 318.—The same case as *Fig.* 317 before operation.

FIG. 319.—The same case after reconstruction operation.

however, I think it is better to retain the head of the femur for its natural purpose, attaching it to the shaft of the femur by an autogenous peg, driven in from above downwards in the way described.

Albee[3] has made what seems a very useful suggestion—namely, to shift the trochanter outwards without quite detaching it from the shaft (*Fig.* 320).

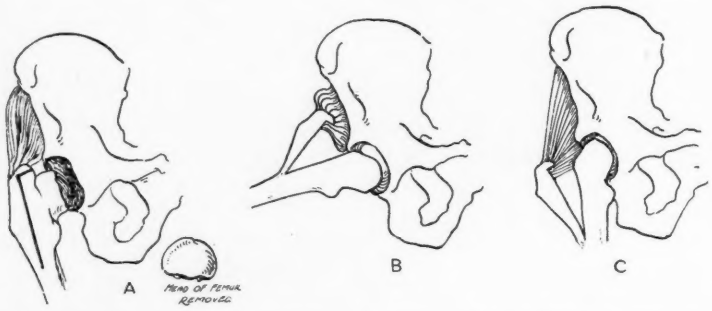


FIG. 320.—Diagram of Albee's operation. A, Shows line of division of the femur after removal of the head; B, Trochanter separated, leg abducted; C, Leg brought down, trochanter forming an outstanding piece of bone.

He does this by a longitudinal cut down the point of junction between the trochanter and the shaft, breaking the trochanter outwards by a partial fracture held in position by the periosteum and soft parts. The limb is put up in abduction, and when consolidation has occurred the trochanter will be an outstanding piece of bone which will give the abductor muscles attached to it considerable mechanical advantage.

3. In the third group of cases the femoral shaft has become displaced upwards, and the limb is consequently 2 or 3 in. shorter than its fellow, with all the characteristic lameness that is associated with dislocation of the hip. Such cases are fortunately not very common, and their origin is rather obscure. The cases I have seen

FIG. 321.—Late case of fractured neck of femur before operation.

have been in young men who have had no severe accident, so that the deformity has developed insidiously and has been regarded as congenital dislocation. It is probably an extreme displacement of the epiphysis, overlooked at the time of its occurrence. It is distinguished from dislocation by the fact that a well-shaped head of the femur lies in the acetabulum, which is of normal size.

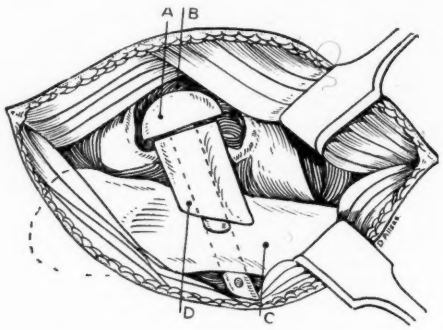


FIG. 322.—Diagram of operation for case seen in *Fig.* 321, showing reconstruction of neck. A, Head of nail; B, Acetabulum; C, Shaft of femur; D, New neck made from the shaft of the opposite femur.

It presents a very difficult problem, and clearly each case will have to be treated on its own merits.

In one case (*Fig.* 321), a man of 41, the following method was used with success. The affected leg was first pulled down by pin and weight traction till it was only 2 in. shorter than the sound side. The femur of the sound leg was shortened by taking $2\frac{1}{2}$ in. from its shaft, the bone being united by an intramedullary peg. The old head of the femur was removed from its socket and a new head formed by an ivory nail, which was made to fix the graft taken from the other femur against the shaft, so forming a new neck (*Fig.* 322). The patient is now, four years after the operation, able to lead an active life, and the two legs being of the same length he is not handicapped by having to wear a high boot (*Fig.* 323). If this operation had to be carried out again, I would modify it by utilizing the head of the femur, fixing it to the shaft by the interposition of the new neck taken from the shaft of the opposite side.

FIG. 323.—The same case as *Fig.* 322 one year after operation.

ANKYLOSIS OF THE HIP.

Ankylosis of the hip requires surgical intervention only when it is bilateral or associated with fixation of the knee, or when it is the seat of very severe pain. There are three operations commonly done for this condition : excision of the head of the bone, Murphy's operation of remodelling both articular surfaces with the interposition of a fascial flap, and Jones's operation, in which the neck of the femur is divided and the trochanter sawn off and fixed to the proximal part of the neck. About the second and third of these methods I do not propose to speak at any length. Murphy's operation has always given very disappointing results in my hands, and I have heard the same opinion expressed by others. It is long and severe and is followed by great tenderness, so that movement cannot be borne for several weeks, and then so much fixation has occurred that it seems questionable whether the operation was worth while. Apparently the interposed fascia becomes quickly adherent to both raw bone surfaces and this brings about a fibrous ankylosis from the outset. Jones's operation, on the other hand, gives the greatest assurance of mobility and freedom from pain, but these advantages are gained at the expense of the stability of the joint, and the patient may be dependent on the use of crutches or a splint for walking. Whilst expressing the objections I feel to these two operations, I would at once admit that I know of no other one which gives uniformly satisfactory results—that is to say, which fulfils the three requirements of a good arthroplasty in giving freedom from pain, mobility, and stability.

Excision of the head of the bone usually gives two of these results—namely, freedom from pain, and stability or mobility—but it rarely gives the last two at the same time. I have been very much struck by the fact that every patient with double ankylosis of the hip on whom I have operated, after having one side done, has come back and begged for the procedure to be repeated on the other side, which may be taken as evidence that the patient does feel a real benefit from the operation, which seems to be only partially successful. On the details of the operation it is unnecessary to dwell, except to emphasize the two important points regarding special steps that are to be taken in order to secure both stability and mobility at the same time. To secure mobility and freedom from pain the head of the bone must be removed entirely, cutting through the neck of the femur. Any conservation of the inflamed head will, I think, lead to renewed ankylosis. To prevent adhesion

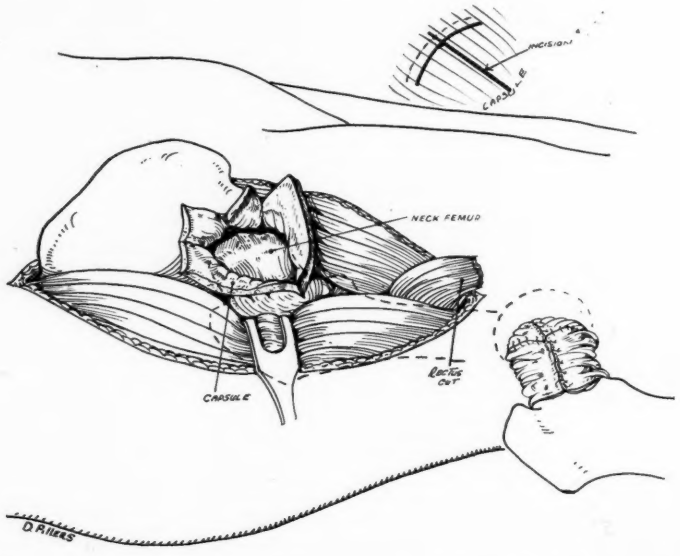


FIG. 324.—Arthroplasty of hip, showing exposure of the neck of the femur by division of the capsule. Inset above, line of capsule division; below, the neck of the femur enveloped in capsule.

of the cut surface of the neck to the rim of the acetabulum, it is better to use the capsule of the joint as an envelope for the end of the femur (*Fig.* 324). In order to do this the attachment of the capsule to the rim of the acetabulum is cut all round the latter and then sewn tightly over the re-shaped neck of the femur. If the cavity of the acetabulum has any remains of cartilage and fibrous tissue lining it, these are not removed. If the socket presents a raw and rough surface, this is well rubbed with Horsley's wax. If the neck of the femur is so short that it will not engage in the acetabulum when the leg is in line with the body, then greater stability may be given to the joint by fixing portions of the head of the femur on the upper margin of the acetabulum in the way which has been described above (*see Fig.* 317).

Another method of preventing adhesions and of giving a good form to the head of the femur is to use a large ivory nail to make a new top to the

bone. The inflamed or ankylosed head is removed by sawing through the neck. A hole is drilled downwards and outwards through the centre of the neck into the shaft. The ivory nail, with a square shaft 3 in. long, and a head which forms a half of a $1\frac{1}{4}$-in. ball, is driven down into the neck and then placed in the hip-joint, where it remains as a new head to the femur (*Figs.* 325–327).

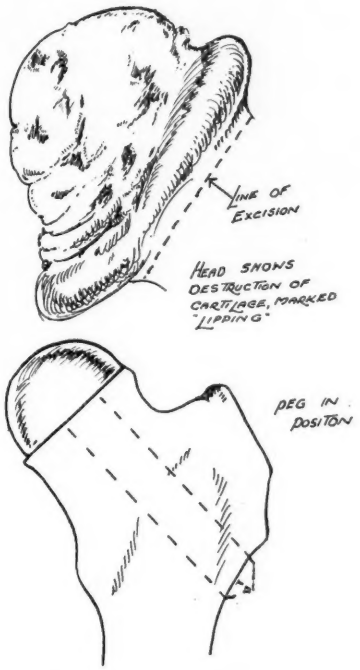


FIG. 325.—Arthroplasty by the use of an ivory nail replacing the head of the femur.

At the time of preparing this lecture a paper by Baer[4] on arthroplasty of the hip has come to hand. The essential of his method is the wrapping of the new femoral head in animal membrane—the submucosa of a pig's bladder chromicized so as to resist absorption for twenty days. I may begin by saying that in the number of his cases (100), the length of his experience, and the excellence of his results, he has surpassed anything to which I can lay claim; but it is interesting to note that he regards 25 per cent movement as constituting a good result. I do not dispute his statement that, as compared with ankylosis, 25 per cent without pain or instability is very good; but one cannot help asking, "Why does this limitation of movement occur?" Baer answers this question by saying that "It is due to the stiffness and unstretchableness of the peri-articular tissues". Probably he is right, and I am confirmed in my idea that it is the capsule which is the fixing agent. If, therefore, the capsule is cut all round its pelvic attachment and made into an envelope for the femur, it will be converted from an agent of fixation into one which facilitates movement.

FIGS. 326, 327.—Skiagrams before and after operation, of a case of advanced traumatic osteo-arthritis treated by the method shown in *Fig.* 325.

CONGENITAL DISLOCATION OF THE HIP.

It is remarkable what a change has occurred in the surgical view as to the possibilities of treatment of this deformity. This change has been due in the first place to the work of Lorenz and other orthopædic surgeons in showing that the hip could be reduced and remain in its socket, if the case was seen early and treated properly. And more recently the later cases of dislocation have been shown to be amenable to surgical treatment, either by open reconstruction of the joint or by some special form of osteotomy. At the present time it may be claimed fairly that congenital dislocation is certainly amenable to treatment at any stage, although the degree of cure will be dependent upon the age at which the case comes for treatment.

The cases may be divided into three classes according to the period of existence of the deformity: (1) In the first—children up to the age of 3 or 4 years—the dislocation usually can be reduced easily by manipulation. (2) In the second—older children from about 4 to 14 years—reduction by manipulation is either very difficult or impossible, but reduction can still be effected by open operation. (3) The third class consists of adults with extreme displacement of the head of the bone and pain due to osteo-arthritis of the false joint. In these reduction is impossible and relief has to be obtained by osteotomy or arthrodesis. The first fundamental point which requires discussion is the relative advantages of the closed and open methods of reduction. And dependent upon this point is the cognate question as to the choice of method for any individual case.

1. **Children from 2 to 4 years.**—Those children of about 2 to 4 years in whom manipulation *easily* reduces the dislocation, present such a perfect functional recovery that it is difficult to see how anything better could be desired (*Figs.* 328–332); but the crux of this proposition is that the reduction must be a simple and an easy matter. I mean by this that, under an anæsthetic, traction followed by flexion, abduction, and rotation should be able to put the head of the femur back into its socket and that it goes back with a click which can be felt or actually heard. In these early cases there is one and only one serious obstacle to reduction, and that is the constriction of the capsule. The head of the femur lies quite close to the acetabulum. It is connected to the latter by a fibrous tube, the capsule, one end of this tube being attached round the margin of the socket and the other round the base of the neck of the femur. After birth, and until the child puts weight on its foot, no marked change takes place, the tubular capsule remaining of about the same length and diameter. Directly walking begins, however, then, the body weight being

FIG. 328.—Pelvis of a girl of 3, showing congenital dislocation of the right hip.

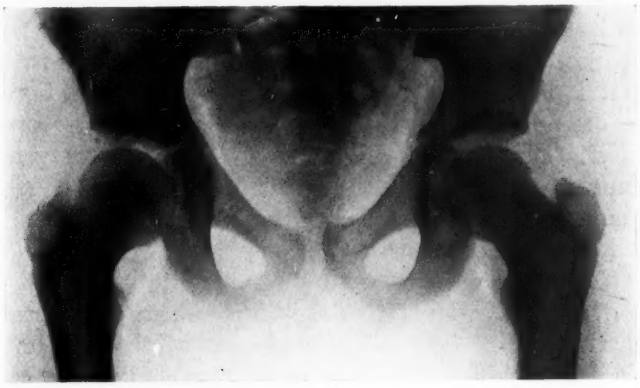


FIG. 329.—The same case as *Fig.* 328 four years later, showing a perfect result after simple manipulation.

FIG. 330.—Pelvis of a girl of 3½, showing double dislocation of the hip, before treatment.

FIG. 331.—The same case as *Fig.* 330 after manipulation.

FIG. 332.—The same case as *Fig.* 331 six years later, with perfect functional result, but showing very shallow sockets.

transmitted from the pelvis to the femur, chiefly by the capsule, the latter slowly stretches, and, as it consists of an empty tube, the more it stretches the more does its middle part sink in to form the so-called 'hour-glass' constriction. In the course of years, as the body weight transmitted by the capsule increases, the tubular ligament becomes thicker and its central constriction narrower, so that at the age of 6 years, when the head of the femur is approximately 1 in. in diameter, the neck of the capsule has a lumen of about $\frac{1}{4}$ in.; also the narrower the inside of the constriction, the greater is the thickness of its walls.

That this is no theoretical conception, but a simple fact, is demonstrated by every case which is submitted to open operation (*Fig.* 333). If, then, the constriction of the capsule is the essential obstacle to reduction, it is difficult to see how this can possibly be overcome either by brute force or by magician's skill applied through the unbroken skin. Possibly the feat may be accomplished in one of two ways. Brute force may actually tear off the attachment of the capsule from the acetabular rim, and then the whole head of the femur with the capsule may be made to fit into the socket; or perhaps a less forcible but more cunning manipulation may telescope the capsule into the acetabulum, folding it up by the pressure of the head of the femur. In either of these events, which must be very unusual, it is possible that if the head of the femur be kept tightly applied to the socket for one or two years, absorption of the capsule may take place, so that at long last the head of the femur comes to lie in its proper cavity. But, on the other hand, I venture to think that in the great majority of instances where repeated and forcible manipulations are applied to a difficult case, and the leg is then put up for a long period in an abduction plaster, reduction is not effected, and however long has been the incarceration of the limb, when the child does begin to walk he does so with a dislocated hip. The sole gain of such a long and expensive method of treatment has been to make the capsule short and thick instead of long and tubular, so that the head of the bone remains for a long time tied closely against the pelvis. I confess that I am utterly sceptical as to the efficiency of any of the complicated methods of reduction, whether they depend upon carefully correlated movements of the limb or upon the force or ingenuity of apparatus, because I cannot see how a spherical body an inch in diameter can be forced through a channel a quarter of this dimension (*Figs.* 334, 335). But cases are still being treated by these methods at a cost of one or two years of time and one or two hundreds of pounds in maintenance fees, only to lead to ultimate disappointment. In children,

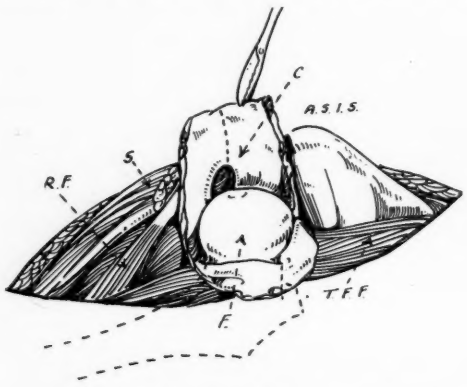


Fig. 333.—Open operation for congenital dislocation of the hip, showing constriction of the capsule. C., Capsule, showing narrow entrance to the acetabulum. S., Sartorius. R.F., Rectus. A.S.I.S., Anterior superior iliac spine. F., Femur, the neck and shaft being shown in dotted line. T.F.F., Tensor fasciæ femoris.

then, congenital dislocation of the hip should always be treated in the first place by manipulation, and it is useful to do this with the guidance of the X rays, so that the head of the bone can be followed as it approaches and enters the acetabulum. As a general rule up to the age of 3 to 4 years manipulation under the guidance of the X rays will effect this reduction, and then if the limb is kept in an abduction plaster for about six to nine months, permanent recovery takes place, so that after a few years no abnormality can be detected in the walking, and the X rays show a normal joint, or one with a shallow socket.

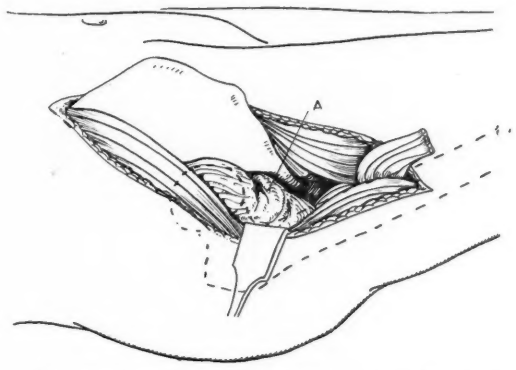


FIG. 334.—Open operation for congenital dislocation, showing the capsule from the outside. A, Constricted portion of the capsule.

2. Children from 4 to 14 Years. — In those children in whom manipulation, aided by an anæsthetic and the X-ray screen, fails to reduce the dislocation, open operation is necessary. These children are generally aged from 4 to 14 years. The hip is exposed by the anterior incision, and the head of the bone in its capsule is usually found lying anteriorly just under the cover of the tensor fasciæ femoris. The capsule is cut open by a longitudinal incision over the femoral head, and it is found that a narrow constriction leads into the acetabulum. The incision in the capsule is prolonged through this constriction, so that the socket is fully exposed. It is now quite easy, by means of manipulation aided by Murphy's shoehorn retractor, to place the head into the socket, but it generally becomes evident that it is not likely to stay in this position because of the shallow character of the acetabulum. At this juncture three courses may be followed :—

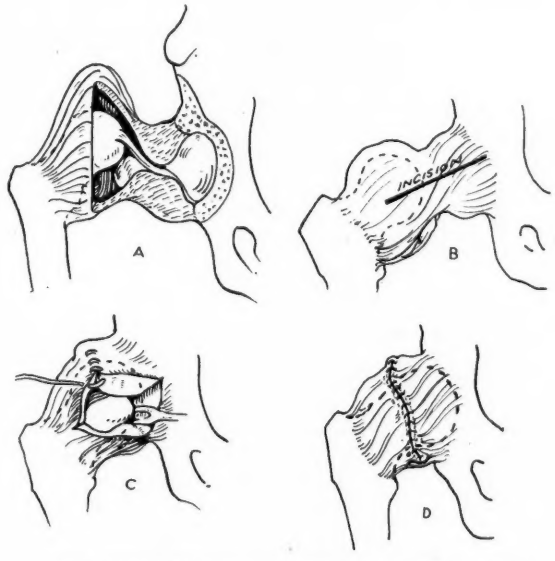


FIG. 335.—Diagram showing structure and treatment of the constricted capsule. A, Hour-glass capsule shown in section ; B, Capsule divided longitudinally ; C, Incision in capsule being sewn up transversely ; D, Completed suture of capsule.

a. The head may simply be kept in its socket by abduction of the limb fixed in plaster-of-Paris, trusting to the pressure of the head to deepen the cavity in which it lies. This plan should be used only in those cases when

the socket is reasonably well formed, as tested by its ability to hold the head when the limb is allowed to lie in the same line as the trunk.

b. The next and most obvious plan consists in deepening the acetabulum by means of a gouge or burr so as to accommodate the whole head, which is then pushed into the new socket and the capsule closed over it. This closure of the capsule will have to be in a transverse direction after the manner of a pyloroplasty, so as to overcome the constriction and at the same time to

FIG. 336.—Pelvis of a girl of 10, showing congenital dislocation of the left hip.

shorten the capsule, tying the femur close to the pelvis. This method of operation has the great merit of gaining good security for the joint, and from this point of view it is the best treatment which is available (***Figs.* 336, 337**). But unfortunately the price paid for this security is the danger that the joint will become fixed (***Figs.* 338–340**). This is accounted for by the fact that the acetabulum is robbed of its cartilage by the act of scooping out a

FIG. 337.—The same case as *Fig.* 336 treated by deepening of the socket, six months after operation. Note the evidence of partial ankylosis.

new socket, whilst the head of the bone, which has been dislocated for a long time, has a very poor cartilaginous covering. This leads to a close fibrous union occurring between the bones. In the case of a unilateral dislocation a firm but more or less fixed hip will give a good functional result, but if the deformity is bilateral then the double stiff hip will give a sadly crippled condition.

FIG. 338.—Double congenital dislocation of the hip in a girl of 12.

FIG. 339.—The same case as *Fig.* 338 a few months after reduction, the sockets having been deepened.

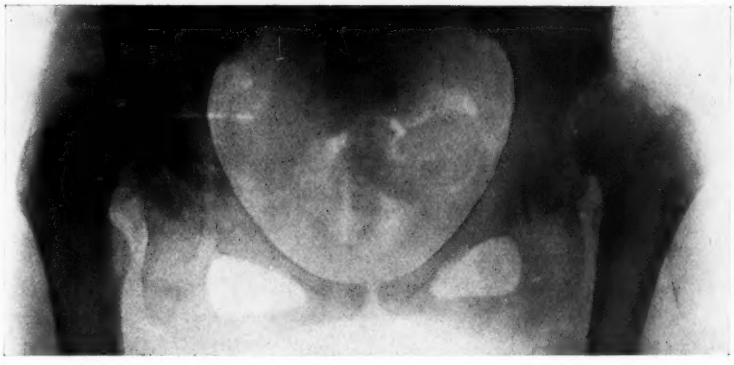


FIG. 340.—The same case as *Fig.* 339 five years after operation. There is some degree of ankylosis.

c. The third available method is to leave the natural cartilaginous floor of the acetabulum and to try to hold the femoral head in place by constructing a new shelf to the upper edge of the socket. This has been done in various ways with varying degrees of success. The method in common vogue is to take a piece of the exposed ilium adjacent to the anterior superior spine and to fix this against the upper margin of the acetabulum by a few bone nails (*Fig.* 341). This is not very efficient, because the bit of bone available, being only $\frac{1}{4}$ in. thick, does not give much of a rim to the socket, and also because this transplanted bone is apt to become absorbed before it can function as an acetabular lip. Another device I have used is that of an ivory rim, which is fixed to the upper margin of the socket by a few ivory nails (*Fig.* 342–345). This remains in place indefinitely (that is, I have cases done four years ago) and the ivory rim becomes encased in new bone. Such a method, however, can hardly be adopted as a standard procedure, because there must be some risk of the bulky foreign body being extruded from the tissues before a new socket has been formed. In all my later cases the new rim of the acetabulum has been made by turning down a wide flap from the outer layer of the ilium. This is not merely periosteum, but a good substantial layer of bone with its covering periosteum. In order to keep it jutting out shelf-wise, one or two ivory pegs are driven in above it. (*Figs.* 346–350.)

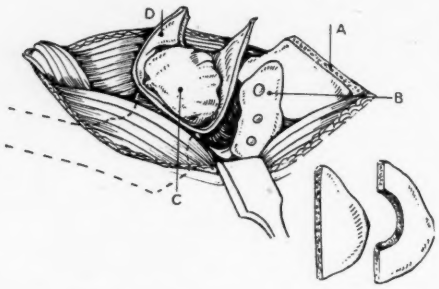


FIG. 341.—Operation for congenital hip dislocation. New rim to acetabulum made by a graft from the ilium. **A**, Cut edge of ilium; **B**, Graft nailed in place; **C**, Head of femur; **D**, Capsule. The inset shows the graft before and after shaping.

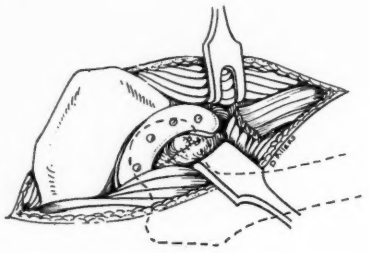


FIG. 342.—New rim to acetabulum made by a piece of ivory.

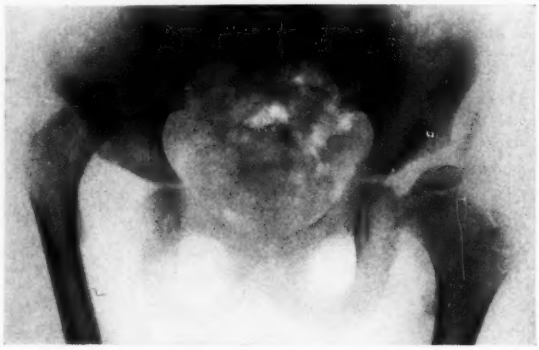


FIG. 343.—Hip-joint of a girl of 10, showing congenital dislocation, before treatment.

It is more than three years now since I began using this technique, and with increasing experience of the operation the results seem to be improving. The new shelf of bone above the acetabulum can be seen in the X-ray pictures to become firm and thick, and it forms the boundary of a new socket of a more shallow type than the normal. As regards functional results, the mobility of these hips remains quite unimpaired, but a slight limp persists owing to the higher position of the femur and the

FIG. 344.—The same case as *Fig.* 343 with ivory rim in place.

FIG. 345.—The same case as *Fig.* 344 two years later.

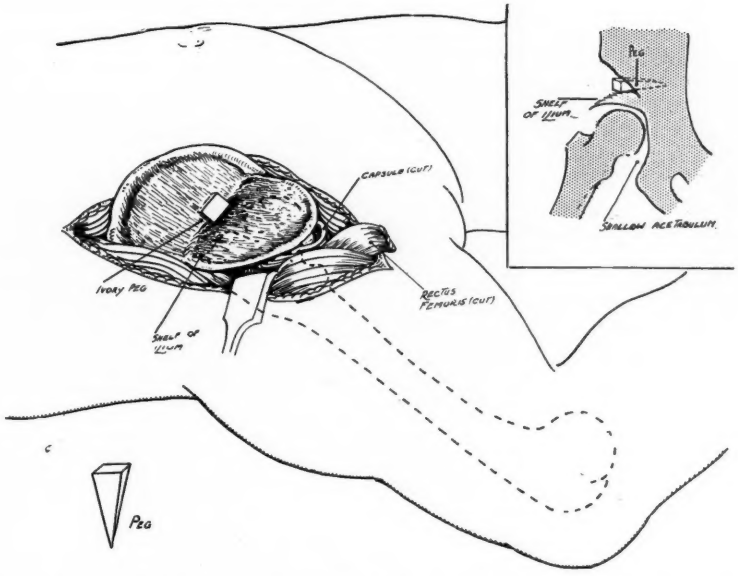


FIG. 346.—Diagram showing new rim made by turning down a bone-flap from the ilium. Insets show the flap in profile and one of the pegs used for holding it in position.

FIG. 347.—Dislocation of the hip before treatment.

FIG. 348.—The same case as *Fig.* 347 one year after treatment by the method shown in *Fig.* 346.

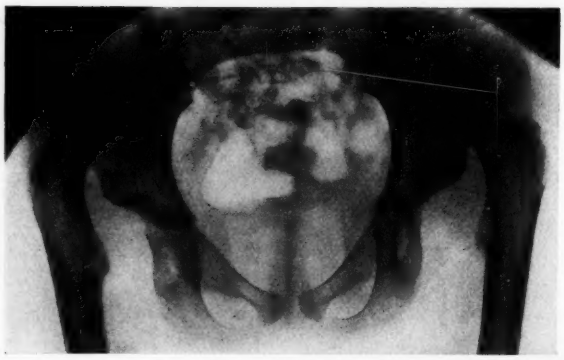


FIG. 349.—Double dislocation of the hip before treatment.

FIG. 350. — The same case as *Fig.* 349 six months after operation by the method shown in *Fig.* 346.

loose fit of the joint (*Fig.* 350). Instead of securing the flap in position by ivory pegs, two converging flaps may be made and secured by sewing their

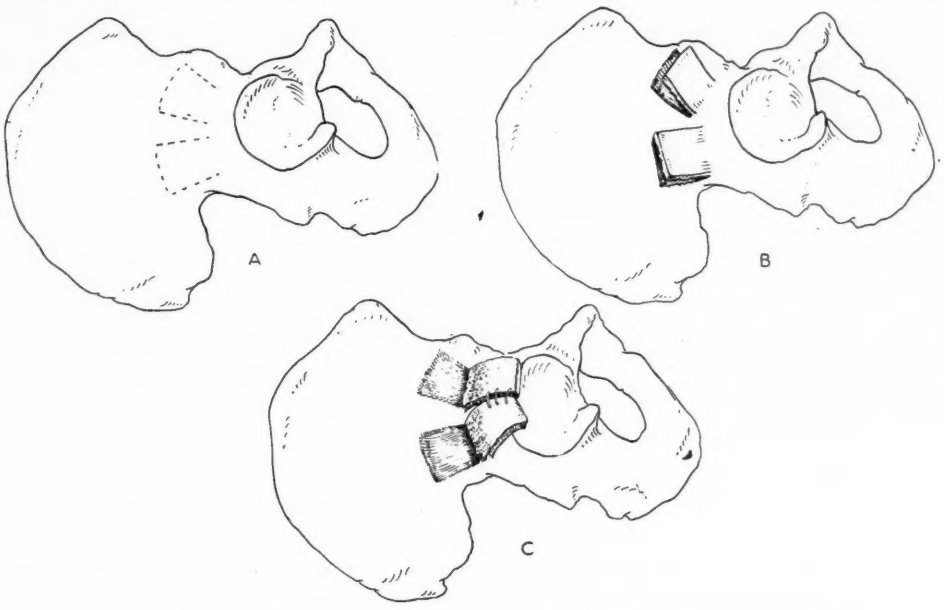


FIG. 351.—Method of making a new rim by converging bone-flaps. A, Lines of flaps; B, Flaps raised; C, Flaps sutured.

edges together (*Fig.* 351). Many years must elapse before the ultimate fate of the reconstructed acetabulum can be demonstrated. In the meantime we have these various methods of treating the dislocated hip which cannot be reduced by manipulation, any of which seem to me to be vastly superior to leaving the child to grow up to increasing pain and lameness.

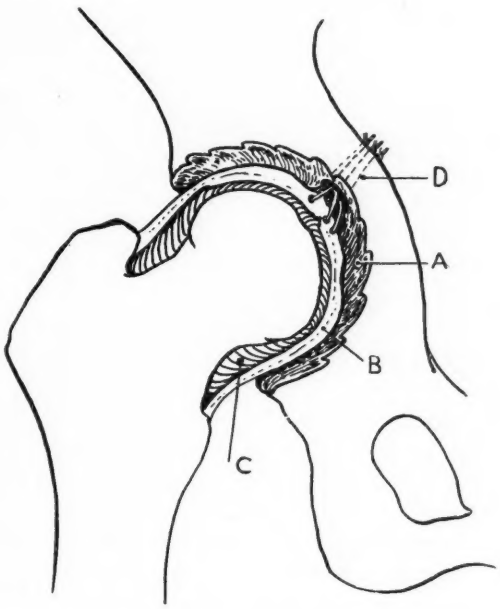


FIG. 352.—Diagram showing deepened acetabulum with the whole capsule detached from the rim of the socket and used to anchor the head in its new bed. A, New acetabulum; B, Capsule; C, Synovial cavity; D, Sutures fixing capsule round the head and brought through the floor of the acetabulum.

In the one method stability is secured by gouging out a deep acetabulum, but with a great sacrifice of the mobility of the joint; in the other free movement is retained in a loose joint, the stability of which is uncertain, by constructing a new acetabular shelf. I still believe that by further

improvement in the technique we shall be able to attain both mobility and stability at the same time. The deepening of the socket is clearly an essential step in securing stability and will always be more efficient than building up a new acetabular rim. How, then, can the fibrous union between the head of the femur and the new socket be prevented? I am trying to effect this by

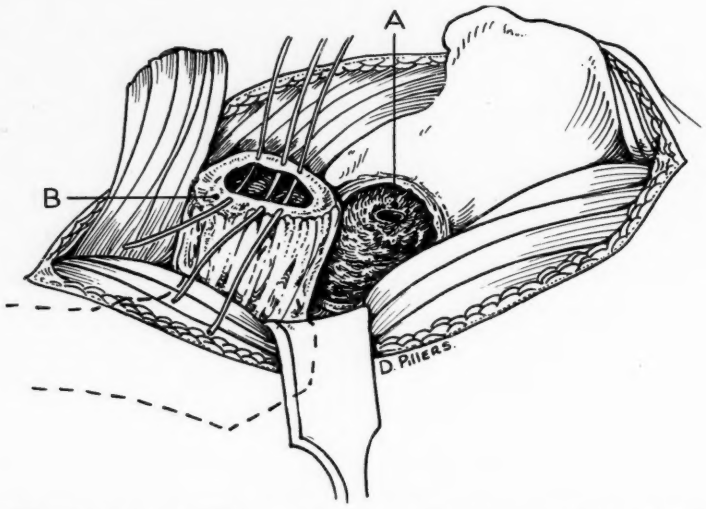


FIG. 353.—Drawing of operation for transplanting capsule inside the acetabulum. A, New acetabulum; B, Cut edges of capsule being sewn together by sutures, which are left long and then taken through a hole in the floor of the acetabulum.

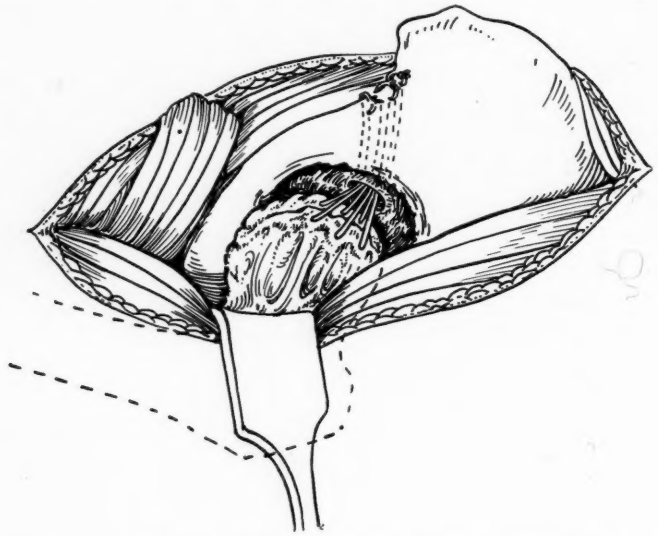


FIG. 354.—Shows sutures drawing the capsule into its new position lining the acetabulum.

the following method (*Fig.* 352). After exposing the head of the femur lying inside the capsule, the latter is not slit open, but its attachment to the rim of the acetabulum is cut away and the constricted part of the capsule is sewn together by a stout ligature so as to enclose the head of the femur by a bag

which has an exuberant margin beyond the ligature. The new socket is then made by gouging out of the acetabulum freely. The floor of this new socket is perforated by a twist-drill, the point of which is controlled by the finger inserted under Poupart's ligament and the iliacus muscle. By means of a suitably curved aneurysm needle a stout tendinous ligature is passed over the pelvic brim, through the hole in the acetabulum, and out into the thigh. The ligature is tied to the free margin of the capsule, the whole femoral head inside the capsule is placed in the new socket, and the free margin of capsule is firmly anchored to the brim of the pelvis or to Poupart's ligament. Thus, although the new socket has been deprived of its cartilage lining, it is now lined by capsule and the head of the bone is still surrounded by its original synovial sac; and, further, the strong capsular ligament with its new attachment will serve to anchor the femur to its socket instead of allowing it to wander away (*Figs.* **353**, **354**).

FIG. 355.—Congenital dislocation of the hip in a man of 20.

3. **Adults.**—The third group of cases of congenital hip dislocation is that of the adults in whom deformity has been endured throughout the resilient period of youth, but who at the age of **25** to **35** usually develop a painful form of osteo-arthritis in the false joint. In such a case true reconstruction of the joint is impossible, because the acetabulum has filled up, the head has become deformed, and the muscles have undergone permanent shortening. In a unilateral dislocation a great deal can be done to cure both the lameness and the pain. The leg, which is about **3** in. shorter than its fellow, is raised about **5** in. off the ground owing to the tilting of the pelvis upwards on the dislocated side, where the hip is always adducted (*Fig.* **355**). A simple subtrochanteric osteotomy followed by forced abduction of the femur will correct the tilting of the pelvis, and by bringing that side of the pelvis down, will to some extent make good the real shortening of the leg. And, what is still more important, the weight of the body, instead of merely being slung on to the femur by the ligaments, will rest upon the thigh-bone at the point where it has been broken and bent (*Fig.* **356**). This is the basis of what is now known as Lorenz' bifurcation operation.

FIG. 356.—The same case as *Fig.* 355 a year after osteotomy. The legs are now nearly of the same length, owing to abduction of the femur and tilting downwards of the pelvis.

Such an operation should be regarded as the routine treatment of all cases of unilateral dislocation in adults; but the problem is more difficult when both hips are affected. The bifurcation operation depends for its success largely on being able to

abduct the leg after osteotomy so that the pelvis will tilt over on that side and so have its weight borne more directly on the femur. Now it is clear that this cannot be done on both sides, because if both legs were abducted, they could not be parallel to one another for walking purposes. In such

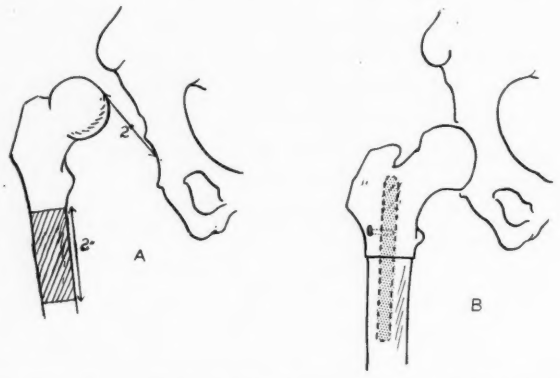


FIG. 357.—Diagram of a method of reducing one hip in double congenital dislocation in an adult. A piece 2 in. long has been removed from the shaft of the femur below the trochanters. This allows the head of the bone to be brought down into its socket.

a case I have used the following method. On the right side the dislocation was reduced by an open operation by the expedient of removing 2 in. of the shaft of the femur just below the small trochanter (*Fig.* 357). This removed the tension of all the great thigh muscles, and the upper end

FIG. 358.—Double congenital dislocation of the hip in a woman of 30. Skiagram of the right hip-joint.

FIG. 359.—The same case as *Fig.* 358 a few months after operation, the femur having been united over a peg.

of the femur could be then brought down so that its head was on a level with the acetabulum, into which it was fitted after the latter had been deepened (*Figs.* 358–360). The divided shaft of the femur was joined by an intramedullary peg. The case was then converted into one of unilateral dislocation,

but with this important difference from the usual condition—namely, that the two legs were of the same length. The patient can now stand and walk without the use of a stick and has 45° of flexion in the hip-joint. I had intended to operate on the other hip at a later date by doing the simple bifurcation operation, but the patient is a working woman and is now free from pain, and so far satisfied with her condition that she does not feel inclined to give up further time for another operation. As the reconstruction operation was done five years ago and she is now steadily at work, it is a good tribute to its efficiency.

FIG. 360.—The same case as *Fig.* 359 five years later. Both legs are of the same length.

INFANTILE PARALYSIS AFFECTING THE HIP MUSCLES.

It is well known that when infantile paralysis involves the lower limb the most serious disability is caused by the loss of the gluteal abductors. The loss of all the muscles below the hip can be made good to a large extent by apparatus which keeps the leg rigid; but the gluteal paralysis, especially that of the gluteus medius, renders it impossible for the body to be balanced on the hip, and so makes it necessary for the patient to be always dependent upon the use of crutches. Two different operations have been proposed for this condition, depending upon the utilization of the tensor fasciæ femoris or the erector spinæ muscles respectively as substitutes for the lost glutei. In Legg's[5] operation the tensor fasciæ femoris has its insertion into the fascia lata fixed to the great trochanter. This is a good procedure as far as it goes, but it is open to various limitations. The new muscle is comparatively small, and as its origin is in front of the line of the great trochanter, it will always tend to flex the thigh at the time that it abducts.

Kreuscher's[6] operation utilizes the lower portion of the erector spinæ muscle. In this procedure there is the great difficulty of providing an adequate tendon to connect the muscle to the trochanter. This has been met by the use of a series of stout silk strands, which it is hoped in time will become reinforced by new fibrous tissue. Obviously, however, it is expecting a great deal to try to balance the body weight on the hips by means of silk strands.

I have adopted a combination of these two operations which seems to me to obviate the objections of each whilst it has the advantages of both (*Fig.* 361). A long incision is made down the outer side of the thigh exposing the iliotibial band of the fascia lata from the level of the trochanter to that of the outer condyle. The fascial band is divided just above the knee and isolated from the deep tissues up to the insertion of the tensor fasciæ femoris. It is then taken backwards through the tendinous origin of the vastus externus just below the prominence of the great trochanter. At this stage the long

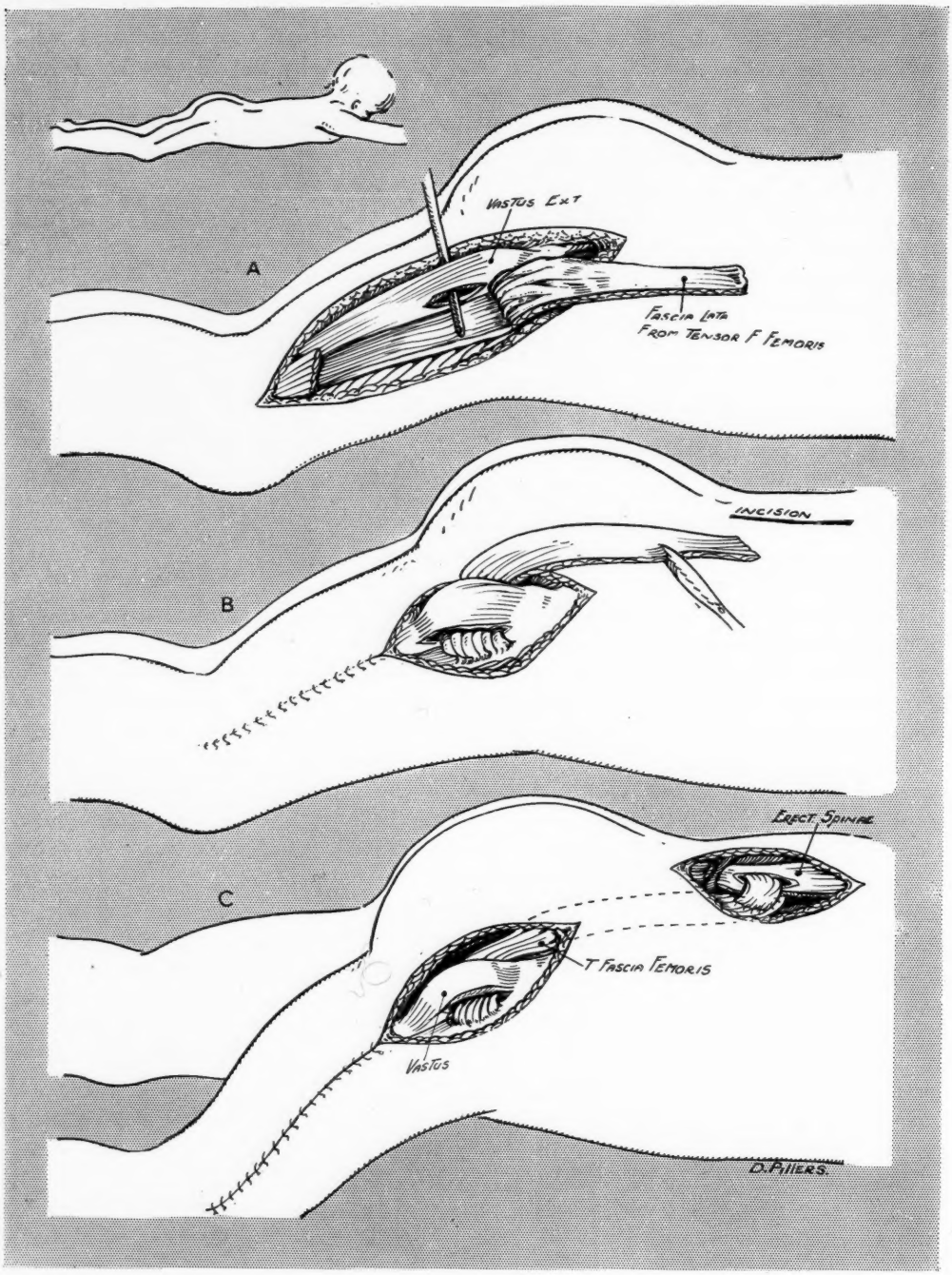


FIG. 361.—Operation for making a new abductor muscle for the hip. Inset, position of the child and incision. **A**, Thigh operation; the iliotibial band is isolated and divided at its lower end. A tunnel is prepared for the new tendon at the base of the great trochanter under the upper part of the origin of the vastus externus. **B**, A great part of the incision is closed; the iliotibial band has been brought through the tunnel at the base of the trochanter. **C**, The superficial part of the erector spinæ has been exposed and isolated; the iliotibial band has been drawn upwards and backwards under the skin and attached to the erector muscle.

incision in the thigh is closed except at the upper part. The lower part of the erector spinæ muscle is now exposed through a separate vertical incision. About half the thickness of this muscle is isolated and divided from its origin at the angle between the iliac crest and sacral spinous processes. A tunnel is made beneath the skin and subcutaneous tissues connecting the two wounds, and the iliotibial band is drawn up to the back, pulled tense, and its end is brought through the tendon of the erector spinæ, doubled back on itself, and sewn by separate stout silk ligatures, the leg being held in abduction all the time and put up in this position after the closure of the wounds and the conclusion of the operation (*Fig.* 362). The new muscle which now forms an abductor of the hip-joint is a digastric muscle having the erector spinæ forming its posterior, and the tensor fasciæ femoris its anterior, belly, whilst the strong fascia lata forms the intermediate tendon. Acting together the two components of this muscle will be a pure abductor, whilst the anterior belly will also be a flexor, and the posterior an extensor of the thigh.

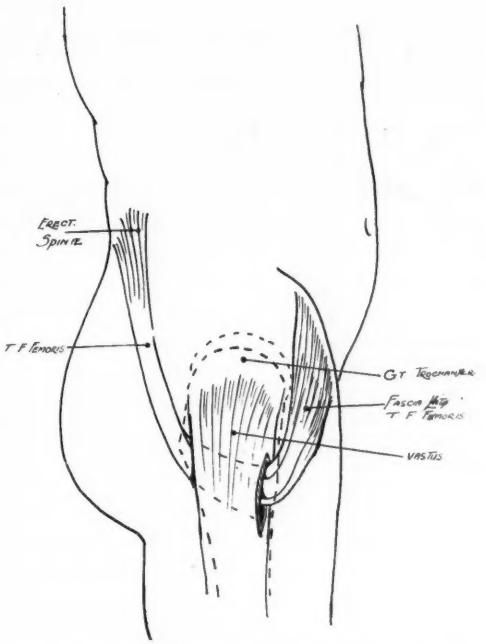


FIG. 362.—Diagram of the new abductor muscle of the hip seen from the side.

In concluding this article, I have to express my grateful thanks to Miss Pillers for the care and skill she has bestowed upon the preparation of the illustrations, which form, I think, its most valuable feature.

REFERENCES.

[1] WALDENSTRÖM, I., *Jour. de Chir.*, 1924, xxiv, 129, abstr. in *Surg. Gynecol. and Obst.*, 1925, Jan., 67.
[2] HENDERSON, M. S., "Ununited Fracture of Neck of Femur", *Jour. Amer. Med Assoc.*, 1926, Jan. 9, 81.
[3] ALBEE, F. H., "Reconstructive Surgery of Hip", *Ibid.*, 1926, Oct. 31, 1345.
[4] BAER, *Jour. of Bone and Joint Surg.*, 1926, Oct., 769.
[5] JONES and LOVETT, *Orthopædic Surgery*, 486.
[6] KREUSCHER, *Surg. Gynecol. and Obst.*, 1925, May, 593.

EXPLORATORY LAPAROTOMY AND APPENDICECTOMY IN CHRONIC AMŒBIC DYSENTERY.*

By VINCENT COATES, Bath, and ERNEST W. HEY GROVES, Bristol.

The following considerations have led us to estimate the desirability of exploratory laparotomy in picked cases of chronic amœbic dysentery: (1) The ubiquity of the *Entamœba histolytica* as reported in the medical journals from time to time. (2) The specific pathology of amœbic infection of the bowel, which is such that there is segregation of amœbæ in blind alleys of the mucous membrane sealed off from the lumen of the bowel by exudate till ulceration occurs. (3) The limited area of mucous membrane exposed to view by the sigmoidoscope. (4) The only occasional success in diagnosing correctly by radiogram localized intestinal lesions amenable to surgical treatment. (5) The repeated failure in many instances to cure or alleviate chronic amœbic dysentery by medical treatment, however protean and varied.

Three cases have been explored surgically. In all three the appendix was removed, and smears from its mucous membrane demonstrated from 8 to 20 amœbæ per microscopic field. In one case the gall-bladder was drained and amœbæ were discovered in the bile. In all three cases amœbæ disappeared from the stools. In *Case* 2, in which the gall-bladder was drained, the attacks of hepatitis were affected favourably both in the matter of lengthening of free intervals and in severity, and in *Case* 3 a desperately ill man was made convalescent.

Case 1.—X., age 33. Complained of tenesmus and frequent passage of blood and mucus. There had been a Flexner-Y infection in April, 1917; agglutination tests were negative; the stools showed much blood-stained mucus, suggestive of old bacillary ulceration, though cultures were negative.

On April 12, 1926, vegetative amœbæ were found. There was nothing to note in systemic examination, except palpable and tender colon. An intensive course of subcutaneous emetine, auremetine and stovarsol by mouth, and emetol in ether and olive oil per rectum made no impression.

Operation, June 14.—Appendicectomy was performed. The stump of the appendix was fixed to the surface incision, through which irrigation was performed. Many amœbæ were found in smears from the appendicular mucous membrane. The amœbæ disappeared from the stools, which otherwise remained *in statu quo*. The general health improved very slightly.

Comment.—A case of double infection, bacilliary and amœbic, which in all likelihood would have responded better to colostomy in addition to appendicectomy.

Case 2.—Y., age 31. Admitted on Jan. 5, 1925, complaining of attacks of pain in right shoulder and right chest with night sweats, every six weeks. Duration

* From The Ministry of Pensions Hospital, Bath.

many months. Free from symptoms on admission. There were no physical signs except finger-clubbing and poor air-entry at the right base. He was apyrexial. A radiogram showed generalized fibrosis of the lungs, most marked at the right base. The sputum was negative on ten occasions; Wassermann reaction negative.

On Jan. 22 amœbæ were found in the stools. An intensive course of emetine periodide produced negative stools.

On Feb. 18 he had an attack of hepatitis. Temperature 102°. Blood-count showed 26,200 white cells, of which 69·5 per cent were polymorphonuclear leucocytes.

He reacted well to emetine hydrochloride, 1 gr. bis die sub cute, and was discharged with full notes to the clinic.

The patient was readmitted to hospital and seen in further attacks similar to the above in character. He reacted to emetine, and there was absence of localized hepatic signs.

Operation, Sept. 7.—A right-angled incision was made at the origin of the right rectus at the xiphisternum, passing laterally to the 10th costal cartilage. Skin flap, rectus, and sheath were folded downwards, the peritoneum was incised, and the abdomen entered. The cæcum showed a granular patch the size of a shilling above the root of the appendix. The appendix was injected, long, and thickened, and was removed. The sigmoid was large. The liver was large and soft, and bled easily on gentle manipulations. There was a yellow patch the size of a threepenny piece on the upper superficial margin of the right lobe. No adhesions were found and no localized abnormality. The gall-bladder, which was small and engorged, was drained.

Smears from the appendicular mucous membrane showed many amœbæ, and they were found in bile from the gall-bladder for five days. The subsequent course was satisfactory.

The patient had one minor attack of hepatitis controlled by emetine, and with stools positive, on Nov. 1, but the stools became negative subsequently after a course of treatment. He was discharged with biliary fistula on Jan. 8, 1926. The case was reviewed on April 21, and there had been no attack of pain since his discharge.

Comment.—A particularly instructive case, where elimination of two culs-de-sac was instrumental in restoring earning capacity to approximately 100 per cent.

Case 3.—Z., age 34, was admitted on Feb. 27, 1926, grossly ill, with tenesmus, tormina, and hourly stools mainly composed of blood, pus, and mucus. There was a slight degree of prolapsus ani. The patient, who had served in the Balkans and Russia, had dysentery in 1918. He was now emaciated, grey, and collapsed.

Amœbæ were found in the stools. Culture was negative to dysentery and typhoid groups. No tubercle bacilli in stools; agglutination tests negative. Complement-fixation tests for tubercle and syphilis negative.

He could not tolerate auremetine by mouth or rectal irrigations. After morphia suppositories, champagne and hypnotics and sodium sulphate at frequent intervals, he tolerated a modified emetine course, and, subsequently, a further more intensive one. The stools remained positive.

Operation, July 7.—The abdomen was opened by a right rectus incision. The gall-bladder, liver, and spleen were normal. The appendix, which was moderately kinked and bound down, was removed. The whole of the cæcum and the ascending, descending, and sigmoid colon was inflamed, especially distally, and much thickened. The tineæ were grossly hypertrophied and stood out like cords. A transverse colotomy was performed, and subsequently a Paul's tube was inserted.

No amœbæ were found on puncture of the gall-bladder, but the appendix showed many of these in its mucosa. Irrigations of permanganate of potash and protargol

were instituted daily, as well as emetol in liquid paraffin. The stools improved very much in appearance, odour, and frequency, and amœbæ have not been found since the operation. At the time of writing the patient is up and about, has put on weight, and feels well. He has an open colostomy wound.

Comment.—The appearance of the large intestine was astonishing, and bore out the impression given before operation that surgical treatment offered the only hope of recovery. The appendix in this instance also appeared to be the jumping-off point for amœbæ.

CONCLUSIONS.

1. The possibility of a specifically infected gall-bladder or appendix acting as a release station for amœbæ should be considered in cases of amœbic dysentery not yielding to medical treatment.

2. There is evidence that, in certain picked cases of this type, removal of such incubation centres has mitigated the course of the disease.

3. Laparotomy is the operation of choice, and the surgeon should be given a free hand to perform cholecystostomy, appendicostomy, or colostomy in addition to appendicectomy as occasion seems to warrant.

We wish to thank the Director General of the Ministry of Pensions Medical Services for permission to make this publication.

CARCINOMA OF THE ILEUM.

By J. J. ROBB, Bristol.

Carcinoma of the small intestine is admittedly somewhat rare, and, judging from a perusal of the literature relating to this lesion, it is still more rare to find it in parts of that gut distant from either the cæcal or duodenal extremities. The nearer one approaches the junction between the ileum and the jejunum, the rarer the condition appears to become. The following case is presented because in its situation it approaches that region of small intestine which, but for such cases, might almost be termed immune to cancerous growth.

CASE REPORT.

The patient was a woman, age 64 years, who came under the care of Mr. Hey Groves in September, 1922.

History.—The patient's complaint was that six months previously she had commenced to have abdominal discomfort and flatulence. Recently her

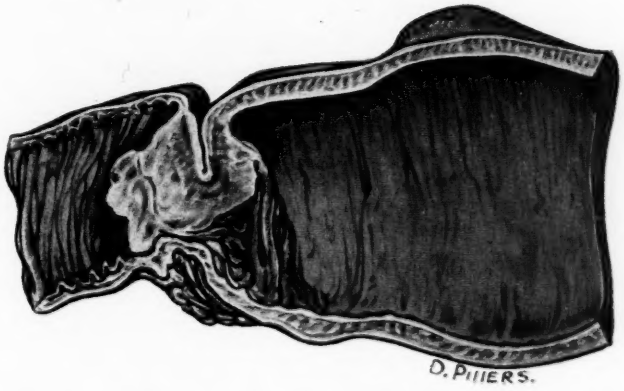


Fig. 363.—Carcinoma of the ileum. The proximal segment of the bowel lies to the right. Extension of the growth has taken place mainly into the lumen, forming a polypoid mass and causing a ring constriction. At the upper part of the stricture the growth has invaded the serous coat. (*The specimen is now in the R.C.S. Museum.*)

appetite had become poor, and occasionally she had attacks of sickness and vomiting. She had lost much weight and was now thin.

On Examination.—There was moderate distention of the abdomen, and coils of intestine could be distinguished. Peristalsis was not visible; the liver dullness did not come below the right costal margin. Per rectum nothing abnormal could be distinguished, and melæna was absent. A provisional diagnosis of chronic obstruction was made and operative treatment recommended.

OPERATION.—Through a median incision below the umbilicus the distended gut was found to be purely small intestine. A small amount of free fluid was present. The cæcum was empty, and further examination revealed a ring constriction about the middle of the ileum. This was excised together with 3 in. of bowel on either side and a V-shaped portion of mesentery. An end-to-end anastomosis was then performed. The left ovary, which was enlarged and hard, was also removed. The right ovary was normal. A section from the left ovary gave the picture of a fibroma.

PATHOLOGICAL EXAMINATION.—An examination was made of the constricting portion of small intestine. At the site of the stricture there was an

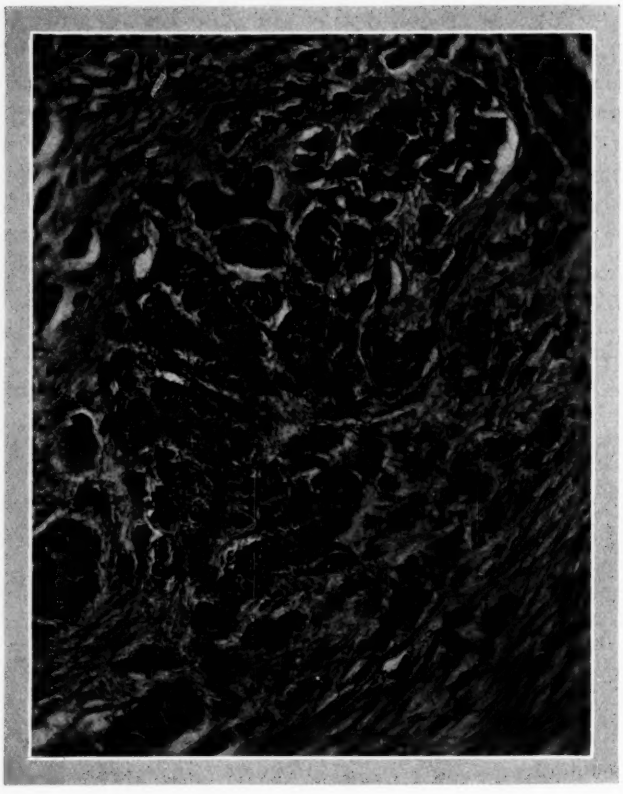


FIG. 364.—Low-power view of section of growth, showing permeation of lymphatics.

inward projecting mass of tissue, which on section showed a highly cellular spheroidal-celled carcinoma (*Figs.* 363, 364). It was growing much more towards the lumen than along the walls of the gut. The lymphatics in the muscular coats at the base of the tumour were infiltrated. Only in one area of the ring stricture was the peritoneal coat invaded by malignant growth. Its spread towards the lumen and its tendency to pass down the lumen caused the stricture, and not its chronicity. There was very little evidence of fibrosis. The highly cellular and undifferentiated nature of the tumour suggested a rapidly growing neoplasm.

Subsequent History.—In the first week of November, 1926, I had the opportunity of examining this patient. She now looks very well, and has added considerably to her weight. Her life is an active, busy one, but she feels quite equal to it, and in every respect is free from symptoms. On examination nothing abnormal can be either seen or felt.

Presenting this case in conjunction with other recorded cases, I venture to give a short account of the main symptoms. There is usually a preliminary history of vague abdominal discomfort, with a varying distention, lasting in the average case from three weeks to six or eight months. These symptoms do not obtrude themselves very markedly upon the attention of the patient, and call for little further remedy than the loosening of some constricting garment. This early lack of evidence of so malign a condition is doubtless due to the fluidity of the intestinal contents. Pain is absent because there is neither trauma nor infectivity of bowel contents sufficient to erode the invading growth, and for the same reason melæna is absent, and also its usual accompaniment, a secondary anæmia. Hence, until obvious obstructive symptoms commence there may be little available evidence to call one's attention to the serious nature of the lesion present.

Once a true progressive obstruction is established, either by stenosis of the small bowel or by a polypoid mass, the symptoms become more characteristic: distention with abdominal pain, vomiting and increasing constipation, often marked emaciation, and loss of appetite. Neither visible peristalsis nor melæna appears to be present as a rule until the very late stages.

Generally these cases are first seen with the symptoms of a subacute obstruction of the small bowel, but may appear as an acute obstruction, particularly where an intussusception has resulted from the passage of the polypoid type down the lumen of the intestine.

In searching the literature on this subject, whether British, American, or Continental, one is at once struck by the rarity of the cases where an actual diagnosis of carcinoma of the small bowel was reached prior to operation. In several cases a bismuth meal and X-ray picture failed to demonstrate its presence. The more one reads, the more one is driven to the conclusion that the whole clinical picture is such that it betrays one's clinical sense; so often the patient has none of those symptoms that suggest the possibility of a cancerous condition. In this article particular stress is laid upon symptoms and the question of diagnosis, because little attention up to the present has been given to their interest—the interest of correlating the pathology and its situation with the clinical picture, most writers being content to point out one or other feature of the condition as being unusual. In collecting the cases on record it will be seen that carcinoma of the small bowel is about twice as common in men as in women, and rather more than twice as common in the ileum as in the jejunum.

It is impossible to be dogmatic about the question of prognosis from records which vary in details and are sadly lacking in length of post-operative history. From what immediate evidence is available two points suggest themselves: (1) The earlier the case receives treatment, the less is the operative risk, and the more certain is the recovery; and (2) The higher up the small bowel the growth is, the worse is the outlook.

Macroscopically one can place these primary growths all under one of three varieties—namely: (1) Stenosing or ring stricture; (2) Polypoid; (3) Multiple carcinomata or carcinoids. Degenerative changes may be found, particularly in the first two types, such as ulcerative and colloid. Cytologically they are columnar- or spheroidal-celled carcinomata. The type of cell present, again, gives us no guide to prognosis, about equal numbers producing metastases either at or shortly after operation.

I have neither particularly included nor discussed the question of the carcinoid in this article, because from a diagnostic point of view it in no way varies from the true carcinoma, and writers are satisfied that if removed its prognosis in no way varies from the well-recognized carcinoid of the appendix.

I wish to express my indebtedness to Professor Hey Groves, who kindly permitted me to present the features of this case for publication.

BIBLIOGRAPHY.

HINZ, *Arch. f. klin. Chir.*, 1912, 305.
FAGGE, *Trans. Clin. Soc.*, xl, 90.
TATLOW, *Lancet*, 1912, i, 991.
VENOT and PARCELIER, *Rev. de Chir.*, 1913, xlvii, 678.
VOELCKER, *Trans. Pathol. Soc.*, 1893, xliv, 88.
BUNTING, *Johns Hop. Hosp. Bull.*, 1904, xv, 389.
KROMPECHER, *Ziegler's Beitr. z. pathol. Anat.*, 1919, lxv, 79.
BAKKE, *Med. Rev. Bergen.*, 1921, xxxviii, 193.
SCHWARTZ, *Bull. et Mém. Soc. de Chir.*, 1921, xlvii, 679.
JOHNSON, *Brit. Jour. Surg.*, 1921–22, ix, 422.
FLEISCHNER, *Wien. med. Woch.*, 1921, lxxi, 2129.
MÉRIEL and SOOREL, *Bull. et Mém. Soc. anat. de Paris*, 1922, xcii, 183.
FREUDENTHAL, *Hospitalstidende*, 1922, lxv, 785.
JEAN, G., *Bull. et Mém. Soc. anat. de Paris*, 1922, xcii, 376.
MINIVELLE, Paris, 1924.
GRAVIER and ROCHET, *Bull. de l'Assoc. p. l'Etude du Cancer*, 1923, xii, 444.
DIDDENS, *Nederl. Tijds. v. Geneesk.*, 1924, lxviii, 2028.
BRISSET, *Bull. et Mém. Soc. nat. de Chir.*, 1925, li, 658.
PRIMROSE, A., *Trans. Amer. Surg. Assoc.*, 1925, xliii, 401.
LYNCH, P. P., *Jour. Pathol. and Bacteriol.*, 1925, xxviii, 394.

SHORT NOTES OF RARE OR OBSCURE CASES

A RARE CASE OF INTESTINAL OBSTRUCTION.

By CECIL P. G. WAKELEY, London.

Intestinal obstruction due to malignant stricture of the small intestine is a very rare condition. On examining the surgical and post-mortem records at King's College Hospital for the years 1900 to 1923 inclusive, only two cases of carcinoma of the small intestine are to be found, and in one of these the diagnosis was not confirmed by microscopical examination. The case reported below is of interest, not only on account of the rarity of the condition, but also because of the difficulty in the actual diagnosis. The following is the history of the case :—

Mrs. E. T., age 53, first complained of abdominal pain in October, 1923, ten months after her menopause. The pain was chiefly in the epigastrium, but was often referred to the hypogastrium. On examination a large uterine fibroid could be palpated in the hypogastrium. She was admitted to the Samaritan Hospital, and in January, 1924, my colleague Mr. W. Gilliatt performed a subtotal hysterectomy for fibroids ; the left ovary was removed because of its cystic condition, and the appendix was also removed. There was no sign of obstruction, and the intestine was not distended.

In April, 1924, four months after her operation, the bowels began to be troublesome, very strong purgatives having to be taken to produce an action. The abdomen became distended, and there was occasional vomiting. The abdominal distention became more marked, and the patient was admitted to King's College Hospital on May 1, 1924. On examination, the abdomen was very distended except in the flanks ; the signs seemed to point to obstruction in the small intestine. A specimen of the vomit was examined, and considered to be a regurgitant vomit from the small intestine owing to the presence of fatty acids and soaps. A provisional diagnosis of obstruction to the lower part of the small intestine was made, and the question as to whether the terminal loop of the ileum had become adherent to the stump of the cervix was raised. This, however, was ruled out of court because of the long time which had elapsed between the operation of subtotal hysterectomy and the commencement of symptoms of obstruction. As the symptoms did not improve, a laparotomy was decided upon.

On May 3 the operation was performed under stovaine anæsthesia, a little open ether also being given. The abdomen was opened just to the right of the mid-line by a sub-umbilical incision. The small intestines were found to be distended, while the large gut was collapsed. A small, hard, annular growth

was found in the ileum about 1½ in. from the ileocæcal valve. The stump of the cervix was quite free, and there were no adhesions in the pelvis. A lateral anastomosis was performed between the lower part of the ileum and the upper part of the ascending colon, and the abdomen closed. The wound healed soundly and the abdominal distention disappeared. On May 19 the abdomen was again opened under stovaine and ether anæsthesia, by a right rectus incision. The short-circuited portion of the gut was excised, namely, the last six inches of the ileum, the cæcum, and the lower part of the ascending colon. The abdomen was closed in three layers. Recovery was uneventful.

FIG. 365.—Specimen after removal. The constriction can be seen just proximal to the ileocæcal junction.

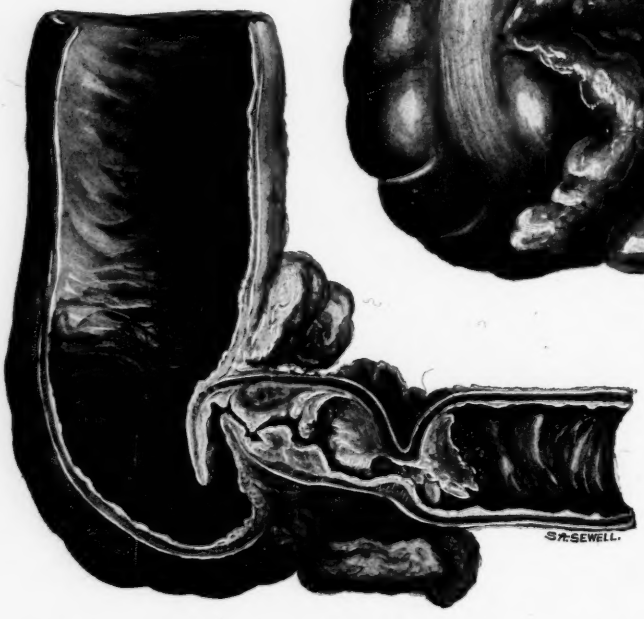


FIG. 366. — Longitudinal section of the specimen, showing the annular growth.

The tumour (*Figs.* 365, 366) formed a tight annular stricture, and on microscopical examination proved to be a columnar-celled carcinoma. There was no sign of growth in the glands at the root of the mesentery or in those in the ileocæcal angle.

When seen last in June, 1926, the patient was in good health. The abdomen was soft, and there was no evidence of any secondary deposits. The bowels were open once a day, and there had never been any irregularity since the last operation.

STRANGULATED HERNIA IN AN INFANT OF 5 DAYS.

By S. J. H. GRIFFITHS, Bristol.

Records show that the occurrence of a true strangulation of a hernia in infants is an event of extreme rarity. Estoei[1] conducted an exhaustive inquiry and found that in 139,000 cases upon which herniotomy was performed in children there was no record of the operation being performed for strangulation. Anel's analysis of 10,000 cases of herniotomy performed at the Edinburgh Children's Hospital includes no instance of complete strangulation. Fraser[2] advances the belief that the early incidence of a strangulation is related to the attempt at natural closure of the processus vaginalis. The local evidence of the attempt is a fibrous ring which is the constricting factor producing the strangulation. The following case not only tends to support Fraser's theory, but appears to be of sufficient interest and rarity to be worth recording.

H. C., a male child, age 5 days, was admitted to the Hackney Hospital at 5.30 p.m. on July 17. The child was apparently normal at birth. It had vomited several times since birth. On July 16 the nurse noticed that the left testicle was swollen, and on the day of admission that it was tender to the touch. The bowels were open the day before admission.

On Admission.—There was a tense swelling in the left side of the scrotum extending into the inguinal canal. The skin over the swelling was somewhat reddened. After unsuccessful attempts at reduction by taxis the diagnosis of irreducible hernia was made, and the child placed in a cot with its feet suspended from a gallows and an icebag applied to the swelling. At 8.0 p.m. there was no sign of reduction, and as the child had vomited several times and the redness of the swelling was increasing, the diagnosis was altered to that of strangulated inguinal hernia and operation thought to be imperative.

Operation.—Under gas and oxygen anæsthesia an incision was made over the swelling. Upon opening the sac about 9 in. of somewhat lustreless discoloured and distended small gut was found. The testicle was swollen and œdematous. With difficulty a hernia director was passed and the constriction, a fibrous ring at the neck of the sac, divided. The site of constriction showed several petechial hæmorrhages. The gut was considered viable and returned to the abdomen. The sac was ligated and removed, and the inguinal canal closed by suturing the conjoined tendon to Poupart's ligament posterior to the cord. The aponeurosis of the external oblique together with the fascia of Scarpa and Camper were sutured in one layer with catgut anterior to the cord. The skin was closed with continuous Japanese silk. The following day the child passed a quantity of blood per rectum and vomited three times. After that its convalescence was uninterrupted, and it was discharged five days after the operation in order that it might resume breast feeding.

I am indebted to the Medical Superintendent, Dr. W. Brander, and to Dr. G. M. Gray, late Resident Medical Officer of the Hospital for Sick Children, Great Ormond Street, who kindly administered the anæsthetic and gave much helpful advice as to the post-operative feeding.

REFERENCES.

[1] Estoei, *Rev. de Chir.*, cxl.
[2] Fraser, *Surgery of Childhood*, i.

A CASE OF STRANGULATED OBTURATOR HERNIA.

By G. L. WALKER, Leeds.

S. A., a somewhat frail old lady, age 73, was admitted to the General Infirmary at Leeds under my care. The history was one of abdominal pain and colic of several days' duration, with persistent pain down the front and inner side of the right thigh. Shortly before admission the failure to pass flatus, together with increasing abdominal distention and vomiting, made a diagnosis of intestinal obstruction fairly certain. An examination of all the hernial orifices gave no information; the possibility of an obturator hernia was considered very likely, and it was decided to open the abdomen.

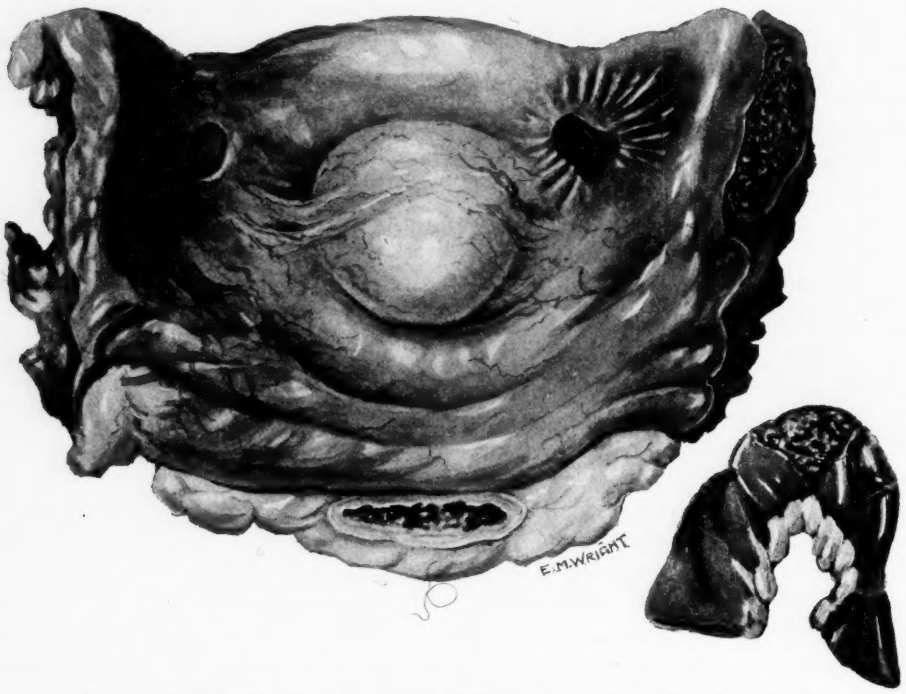


Fig. 367.—Showing the front wall of the pelvis and the knuckle of gut.

An incision was made in the middle line of the abdomen under local anæsthesia, supplemented later by general anæsthesia, and a knuckle of small intestine was found held down in the right obturator canal. It was freed and the gangrenous portion of the gut wall was infolded. Lateral anastomosis was performed on the loop of intestine.

Unfortunately the patient did not rally well, and died a few hours after relief.

Fig. 367 shows the specimen removed. The infolding of the gut has been undone, and the appearances suggest that the bowel has been a long-continued occupant of the hernial sac, with a recent strangulation of Richter type.

THE LATE RESULTS AFTER AN OPERATION FOR EXSTROPHY OF THE BLADDER.

By T. A. ROBINSON and GORDON S. FOULDS, Toronto.

It is not our intention to discuss the relative merits of the various types of operation devised in the treatment of exstrophy of the bladder, but rather to report the present condition of one of the original five cases operated on by the late Dr. George Peters by the method described by him. In 1901 Peters[1] published the report of his first case which had been operated on in 1899 for exstrophy of the bladder and prolapse of the rectum. In 1902 three more patients were operated on. His last case, the subject of this report, was treated in 1903 and 1905. The account of this last patient was published in 1908 by Starr[2] after Peters' death. At this time four of these original cases were alive and in good health.

REPORT OF THE CASE.

George R., age 23 years, a lather by trade, was admitted to the University surgical wards of St. Michael's Hospital, Toronto, on Dec. 6, 1924. He complained of pain in the right loin and loss of weight and strength. For one month he had had pain in the right side of the abdomen. At first it was crampy in character, but later became steady and boring. About one week before coming to the hospital the pain had extended up into the right loin. He had been confined to bed for two weeks.

History.—The patient was born with ectopia vesicæ. When 16 months old, he was admitted to the Hospital for Sick Children on March 9, 1903, because of a left inguinal hernia, which was reduced under general anæsthesia. The hernia recurred ten days later. A herniotomy was done on this occasion by Dr. G. A. Peters, and the patient left the hospital on April 28.

On June 28 he was again admitted to the Hospital for Sick Children for prolapse of the rectum. Dr. Peters operated on him according to his original method,[1] opening through the left iliac fossa. About half a dozen sutures were placed in the bowel so as to constrict its lumen. The bowel was then stitched to the fascia covering the iliacus muscle. The patient made a good recovery and left hospital on July 6, 1904.

On Oct. 13, 1904, he was again admitted to hospital, but his general health precluded operation until Jan. 24, 1905, on which date the ureters were transplanted by the extraperitoneal method into the rectum, and the remainder of the bladder wall was ablated. His recovery was slow, but by April 24, the abdominal wounds were healed and the patient was discharged from hospital in good condition.

Since then he attended school from the age of 7 until he was 14 years old. He later worked as a messenger boy, and afterwards for one year made

his living wrapping parcels. For the past three years he has worked as a lather. During these years he has had fairly good control of the general bowel content, but occasionally the sphincter ani would fail to retain the urine.

On Admission.—The temperature was 101·2°. There was a mass in the right loin which extended forward to the abdominal wall. It was very tense, painful, and tender. There was moderate œdema of the back over the mass. The heart and lungs were apparently normal. The white blood-count was 18,000.

Operation.—Under general anæsthesia an incision was made just below and parallel to the 12th rib. About a quart of foul pus was evacuated from the perirenal tissue and from the kidney. The pelvis of the kidney which was open contained calculous material. The ureter was dilated to about ¾ in. in diameter and contained soft calculous masses. Two drainage tubes were inserted, and the wound was closed.

Post-operative Course.—The patient made a fair recovery. Moderate amounts of pus discharged from the wound for three weeks, and afterwards a small sinus persisted.

Studies of the renal function were made, and the blood-urea nitrogen was found to be 20 mgrm. per 100 c.c. of blood on April 20, 1925. It was our intention to remove the kidney later, but on consideration it was decided that further interference was inadvisable on account of a transitory infection which occurred in the left kidney. The patient is now continuing his trade, and is in fairly good health despite the small sinus, which persists. X-ray examination before discharge showed no evidence of stone in the left kidney, but some calcareous material persisted in the right renal area.

According to Mayo and Walters,[3] statistical records show that 50 per cent of all persons with this unfortunate developmental defect die, if unrelieved, before the 10th year, and that 66 per cent die before the 20th year. That four of Peters' five cases survived until 1908 at least, and that this case should be alive and able to carry on in his trade twenty-one years after his operation, seems worthy of record.

REFERENCES.

[1] Peters, George A., "Transplantation of Ureters into the Rectum by an Extra-peritoneal Method for Exstrophy of the Bladder, *Brit. Med. Jour.*, 1901, 1538.

[2] Starr, F. N. G., "Exstrophy of the Bladder: the Peters Operation", *Canad. Jour. of Med. and Surg.*, 1908, xxiv, 132.

[3] Mayo, Charles H., and Walters, W. W., "Transplantation of Ureters into the Rectum. End-results of Thirty-five Cases of Exstrophy of the Bladder", *Jour. Amer. Med. Assoc.*, 1924, lxxxii, 624.

A CASE OF ENCRUSTED CYSTITIS.

By ALEX. E. ROCHE, London.

We read in Cabot's *Urology* that "an occasional complication of a rebellious alkaline cystitis is encrusted cystitis"; that "the pathogenesis of this disease is no more definitely understood than is that of encrustation elsewhere"; that "a characteristic and almost pathognomonic symptom is the repeated passage of calcareous material in the urine"; and that "most of the afflicted individuals have been finally forced to undergo surgical interventions".

A case illustrating these points is that of C. P., a builder, age 42, admitted to St. Peter's Hospital, Covent Garden, on Feb. 15, 1926, under the care of Mr. Swift Joly, to whom I am indebted for permission to publish it.

History.—The complaint was of pain on, and increased frequency of, micturition, and also of the passage of stones and 'blood-streaked jelly'. The past history vouchsafed included six months' residence in Egypt during the war (where he had one catheter-relieved stoppage); pneumonia and malaria; but not venereal disease.

About two years before being admitted to St. Peter's Hospital, the commencement of slowly progressive increased frequency of micturition was noticed both by day and by night, occurring finally at half-hourly intervals. About nine months before admittance, the patient passed a white stone with pain, and, since then, large numbers of stones, about fifty in the last five weeks (nine during the last week), the passage of each stone being painful and accompanied by dribbling.

There had been occasional dull hypogastric aching for three months and occasional median dorsal pain, but no lumbar or testicular pain. There was no pain on micturition as a rule, though this was preceded by pain at the tip of the penis and in the rectum; there was no difficulty, except on the passage of stones, and no intermittence of the stream; there was urgency, with incontinence if the bladder was not very soon emptied. The urine had been occasionally blood-stained during one month. The patient had had frontal headaches, not worse recently, for two or three years, but no shivering, nausea, or vomiting. Thirst and appetite were normal; the bowels had been constipated for two years.

On Examination.—The patient looked well. The external urinary meatus was red and œdematous; there was no delay, but rather precipitancy, on micturition, and the stream was of fair size. The urine was blood-tinged, contained threads, and was alkaline. There was hypogastric tenderness, and the urethra was tender, but admitted the cystoscope, which revealed two ounces of residual urine; it had to be withdrawn on account of great tenderness on irrigation. On one occasion crepitus was detected on examination per rectum. A radiogram (*Fig.* 368) by Mr. E. A. Collingridge, on Dec. 24, 1925, shows the semicircular outline of the bladder, calcified in its upper part, the prostatic and renal regions being clear of stones.

Operation.—At the operation by Mr. Swift Joly on Feb. 17, 1926, cystoscopy was impossible because of bleeding. A suprapubic cystostomy was performed, and much calcareous matter was found studding the upper half of the bladder, the wall of which was here thickened, velvety, irregular, and finely papillary and nodular, yet quite flexible, and not hard as in carcinoma. The adherent calculous material was scooped off, and similar material, free in the bladder cavity, removed. A de Pezzer tube was tied into the bladder, and a No. 24 (French) catheter into the urethra. Three days before the patient's discharge from hospital on March 15 he passed two small calculous flakes $\frac{1}{3}$ by $\frac{1}{6}$ in. in size.

The localization of the calcifying process to the superior wall of the bladder is curious. The residence of the patient in Egypt might suggest bilharziasis as the basis of the cystitis, were it not for the complete absence of symptoms until at least six years afterwards (with the exception of an isolated retention of urine, the cause of which is obscure). The history and aspect of the patient were unlike those usually met with in carcinoma, which, though not considered at the operation to be present, could not even then be definitely excluded; its presence or absence was to be determined by the further progress of the case.

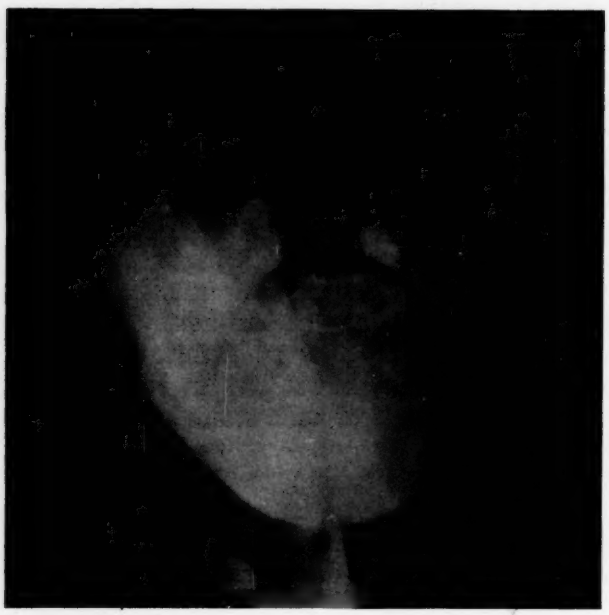


Fig. 368.—Radiogram showing a semicircular shadow of calcareous deposit on the vault of the bladder.

Subsequent History.—The subsequent history is that, since May 3, the patient, who was treated with hexamine and bladder washes, had occasional slight suprapubic leakage; this prevented cystoscopy, as the irrigating fluid escaped when the bladder contained only one ounce. Before May 3 the patient passed one very small piece of calculous material, but has passed none since, and a radiogram taken on June 3 shows no trace of any abnormal shadow in the bladder region. Since May 17, when the urine was still turbid and alkaline, he has been taking hexamine and acid sodium phosphate.

On July 12 the fistula was cauterized down to the bladder with silver nitrate, after which there was less suprapubic leakage. On Sept. 6 the urine was noticed to be clearer, and, for the first time, acid, this acidification being evidence of the diminution of the severe infection (of which a right epididymitis on leaving the ward, and a left epididymitis at the end of

July were further manifestations), and a sign of prime prognostic importance as a guarantee against the recurrence of the phosphatic accumulations, the deposit of which postulates alkalinity of the urine.

On Sept. 29 the suprapubic fistula was completely excised by Mr. Joly, as was also an abscess cavity under the rectus sheath in front of the bladder. There was much pericystitis. The bladder, which felt smooth and soft, was freed from the pubes, to which it was adherent, and completely sewn up, a catheter being left in the urethra. On the seventh day the patient had a right epididymitis, which subsided in three to four days. He was discharged from hospital on Oct. 22, since when he remains suprapubically dry. He has passed no calculous material and has had no pain since May; his weight remains normal, he looks extremely well, and his bladder is known to be soft and smooth, so that carcinoma is excluded.

The case is interesting as illustrating a rare condition, the causation of which is obscure, and the localization curious; it is also gratifying in the relief afforded to the patient from peculiarly unpleasant symptoms.

A CASE OF MULTIPLE URINARY LESIONS.

By ALEX. E. ROCHE, London.

The rule not to diagnose the presence of two lesions when one might suffice to explain the symptoms, though excellent as a general guide, has exceptions, to the possibility of which one must always be alive. When urethral stricture prevents cystoscopy, especial caution is necessary, insidious carcinoma of the bladder being found as an occasional concomitant. The presence of multiple lesions is well illustrated by the case of J. H., an ex-builder, age 78, admitted to St. Peter's Hospital, Covent Garden, on Jan. 9, 1926, for permission to report which I beg to thank Sir John Thomson-Walker.

History.—The patient had had gonorrhœa at the age of 28, and his complaint was of difficulty and pain on micturition. He had had very slight difficulty on micturition for twenty years; this had been progressive till Nov. 5 1925, when a fine stricture was found, and gradually dilated from 2 to 14 (French) by Dec. 17. On Dec. 18 he had retention of urine, relieved by a metal catheter, when grating was felt.

Radiograms by Mr. E. A. Collingridge showed that the renal regions were clear, but that there were many prostatic calculi, and also two large vesical calculi, the lateral position of which might be accounted for by their presence in a diverticulum, or by the occupation of the left side of the bladder by something else, the presence of which seemed to be indicated by an ill-defined shadow (*Fig.* 369).

On Admission.—The patient stated that there was pain throughout the urethra during micturition, and straining to commence the stream, which was narrow, slow, dribbling, and vertical, the best position for micturition being one of forward bending. There had been no stoppage but the one mentioned. There was occasional slight pain in the penis after micturition, lasting

one hour, but not increased by walking or by the jolting of an omnibus. Micturition occurred every two hours, day and night. There had been shivering attacks after instrumentation, and bilateral backache for three months, but no headaches, nausea, or vomiting, or passage of stones. The patient stated that he had passed claret-coloured urine about once a fortnight for three months, the commencement of this period antedating the recent course of instrumentation, previously to which no instrument had been passed for years. The water, he said, had smelt bad for six weeks.

Appetite and digestion were good, the bowels costive, thirst was normal, the tongue clean and moist. The general condition was poor, the breathing laboured, and the chest barrel-shaped and moving '*en bloc*'. There was retention of urine, with hypogastric percussion-dullness up to the navel.

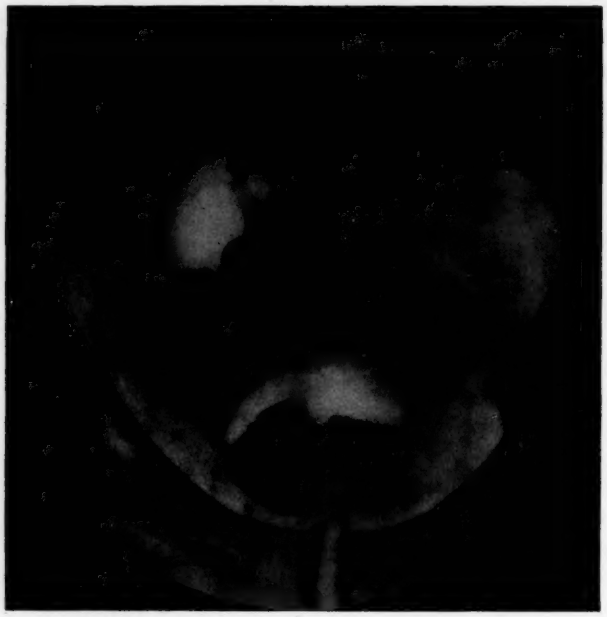


FIG. 369.—Radiogram showing prostatic and vesical calculi and a vague shadow on the left of the bladder region.

A 10 (French) gum-elastic catheter was tied in, and brown urine with a fæcal odour escaped. Further abdominal examination was negative, and rectal examination difficult because of a narrow anal canal and straining. The lower part of the prostate was reached, but no crepitus felt. The urine, of specific gravity 1020, was neutral, and contained pus, but no sugar.

OPERATION.—At the operation by Sir John Thomson-Walker on Jan. 11, 1926, the stricture was dilated with metal bougies from 6/8 to 9/11 (English); 10/12 would not pass. The bladder was opened, and two more or less oval smooth brown calculi were removed. Calculi were felt in the prostate, and an extensive inoperable growth on the left wall of the bladder. Much surface necrotic growth was removed, and the bladder washed out through a urethral catheter, which was afterwards tied in. Drainage was established both of the bladder and of the space of Retzius. The rate of respiration and of the pulse rose on the fifth day, the former being very rattling, and death, a merciful event, occurred on the ninth day from bronchopneumonia and cardiac failure.

END-RESULT OF A CASE OF FASCIAL URETHRAL GRAFT THIRTEEN YEARS AFTER OPERATION.

By R. J. WILLAN, M.V.O., Newcastle-upon-Tyne.

In the British Journal of Surgery, 1918, V, No. 19, I reported a case of "Fascial Grafting for the Repair of Traumatic Stricture of the Urethra". The stricture was behind the level of the deep layer of the triangular ligament; half-an-inch of scar tissue separated the torn ends of the urethra; and no

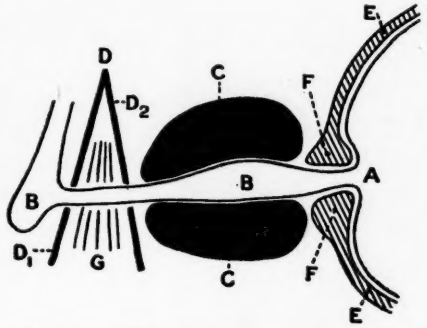


Fig. 370.—Showing the normal relations of the parts.

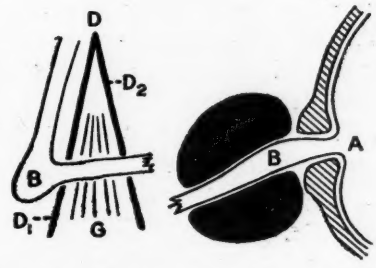


Fig. 372.—Showing the downward displacement of the proximal fragment.

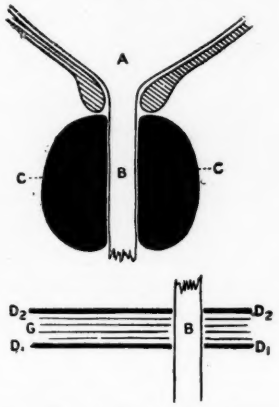


Fig. 371.—Showing the lateral separation of the torn ends.

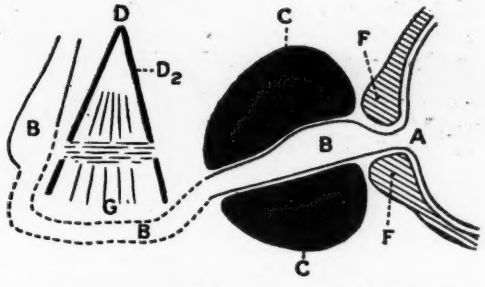


Fig. 373.—Showing the fascial graft (in dotted outline) uniting the penile and prostatic portions of the urethra. The membranous portion has been destroyed, and is replaced by fibrous tissue.

Figs. 370–373.—Diagrams of the prostatic and membranous urethra, etc., illustrating the normal relations of the parts and the conditions in the present case.

A, Bladder. B, Urethra. C, Prostate gland. D, Triangular ligament. D_1, Superficial layer of ligament; D_2, Deep layer. E, Bladder-wall muscle. F, Internal sphincter. G, Compressor urethræ.

instrument could be passed along the urethra into the bladder. The patient, then a man 32 years old, having acute retention of urine, was sent to me with a request that a permanent suprapubic fistula should be established.

The plastic operation on Feb. 5, 1913, consisted of: (1) Destruction of the membranous urethra; (2) Reconstruction of a new portion of urethra,

1¼ in. long. A graft from the fascia lata was used, and *it required to be carried round the lower margin of the triangular ligament.*

On Aug. 7, 1914, a urethroscope showed: "Five inches from the external meatus, the lumen rather narrower than the portion in front; while, instead of being the straw colour of a normal part of the urethra, the new portion was white in colour, like scar tissue. Unlike scar tissue, however, this surface had a 'sheen' on it, due to a covering of epithelium".

I saw the patient at intervals, the last occasion being June 20, 1925, when I demonstrated the case on the occasion of the visit to Newcastle of members of the Interstate Post-graduate Assembly of America. The urinary stream was then a full, forceful one, and a dilating bougie, size No. 15 (English), was passed only at infrequent intervals.

In May, 1926, the patient died suddenly from a condition entirely unconnected with the urinary passage.

The operation can be regarded as a complete success, for the fascial graft amply served its purpose until the patient died, over thirteen years afterwards. Full details of the operation are given in the BRITISH JOURNAL OF SURGERY, 1918, V, p. 494. *Figs.* 370–373 illustrate the normal anatomical relations of the parts concerned and the conditions in the present case.

EXCISION AND RESTORATION OF UPPER LIP.

BY H. P. PICKERILL, NEW ZEALAND.

IN a previous communication to the BRITISH JOURNAL OF SURGERY,[1] I showed a number of cases, chiefly military and therefore in young men, for whom considerable restorations of lost portions of the face had been undertaken by means of tube-grafts—including the double tube-graft flap, which I believe I originated in 1918. It may be of interest now to show the photographs of a civilian no longer young, for whom I did a similar type of restoration last year.

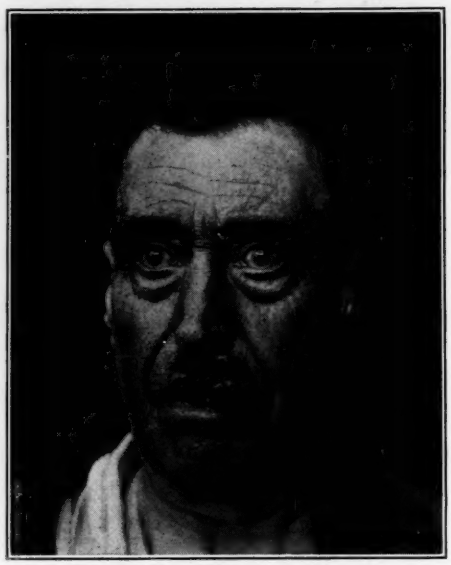


FIG. 374.—Large fungating growth of lip. History of old burn.

The patient, a man of 65, was admitted to the Dunedin Hospital with a large fungating growth of the upper lip about the size of a hen's egg (*Fig.* 374). He gave a history of having received a severe burn on the lip fifteen years ago. It had been slow in healing and had left a 'lump' on the inner surface of the lip; this 'lump' started getting larger about six months ago and had grown rapidly during the last six weeks.

I excised the upper lip (*Fig.* 375) under local anæsthesia and sent the patient into the country for healing to take place and for observation as regards recovery.

The pathological report on the case was as follows: "The section of a piece of tissue from the lip shows a papillomatous type of growth with much more surface cornification than down-growth. The glands of the right and left sides show no evidence of malignancy. It is a slowly growing malignancy supervening on a squamous papilloma of the lip."

Six weeks later plastic restoration was commenced. The first stage was to form the new lip from two flaps, one from the chest for the inner surface

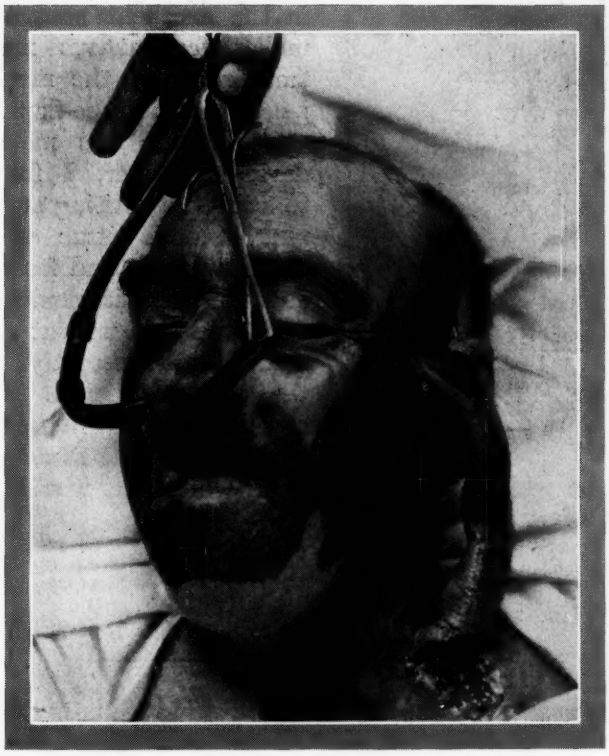


FIG. 375.—Lip excised. New lip formed by double tube-flap and ready for grafting. Photograph taken on operating table.

and one from the scalp for the outer surface. The scalp-flap is superimposed on the chest-flap, united, and allowed to lie alongside the left ear for a fortnight (*Fig.* 375). The lower end is then divided, swung across, and inserted in the prepared bed on the right and upper borders of the excision wound. At the next stage the graft is divided and the proximal end inserted into the left side of the excision wound. The scalp-tube is opened out and replaced. The patient, of course, was enabled rapidly to grow a moustache, with the result seen in *Fig.* 376.

The points of interest in this case are, first, the important fact that comparatively large grafts of this kind can be successfully undertaken for old

patients, a fact to which I have previously called attention. During the war it used to be suggested that grafting of this kind was all very well for soldiers who were young, fit, and not the subjects of any disease, but that such things would be extremely risky or impossible in old people, the subjects, say, of malignant lesions. My experience has been the opposite with regard to either free or pedicled skin-grafts; I am not referring to bone-, cartilage-, or muscle-grafts.

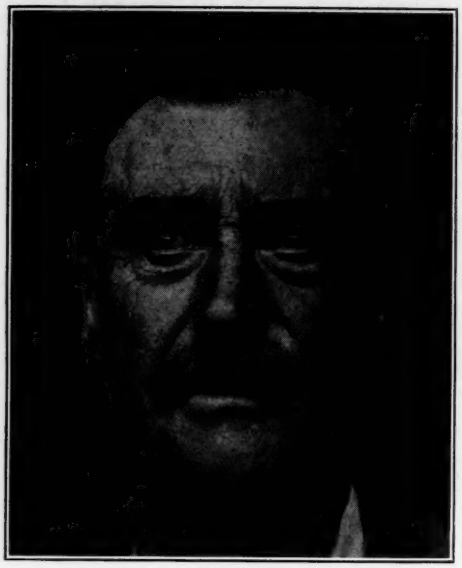


FIG. 376.—New lip grafted. Growth of new moustache unfortunately hides the pink lip-line referred to in the text.

The second point of interest lies in the excellent substitute chest-skin makes for mucous membrane when transferred in the manner described, i.e., by double tube-flaps. When I first started using this method at Sidcup during the war, I found it difficult to convince visiting surgeons that the pink, smooth tissue of the lip which they could see and feel was really skin and not mucous membrane, and when I showed this patient at a meeting of medical men recently I could detect the same scepticism. The extraordinary thing is that if the same skin were grafted into the same area as a free graft, it would be white and would remain white and would never take on the appearance of mucous membrane.

REFERENCE.

[1] *Brit. Jour. Surg.*, 1921, ix, 321.

AN UNUSUAL CASE OF CONGENITAL NÆVUS OF FOREFINGER AND THUMB.

BY L. R. BRAITHWAITE, LEEDS.

A FARMER, age 43, had noticed during the last four years a wasting of the 'tissues' of his right hand, especially the forefinger and thumb. Latterly he had had pain at the tip of the forefinger, and three weeks ago some suppuration with a sanious discharge. He was thought to have a diseased terminal phalanx—possibly tuberculous, possibly an infection from an unnoticed septic wound.

Examination showed a condition well seen in *Fig.* 377. The backs of the hand, forefinger, and thumb showed a remarkable plexus of enormous veins; with the hand dependent these became more marked, and the tip of the forefinger and of the thumb throughout the length of the distal phalanges

became markedly blue and full; with the hand elevated, the same areas in finger and thumb became bright-red and flaccid, the skin falling into longitudinal creases.

FIG. 377.—Congenital nævus. Dorsal aspect.

FIG. 378.—Congenital nævus. Palmar aspect.

The front of the tip of the forefinger showed an open ulcer with small areas of black necrotic tissue and old blood-clot; this area bled easily and very freely when irritated by slight injury, and was markedly tender to

touch. The palmar surface of the thumb showed an area of nævoid tissue edged in by a raised border (*Fig.* 378).

Owing to the persistent bleeding, pain, and discharge from the forefinger, an amputation of this finger through the middle of the second phalanx was performed. The operation was more vascular than usual, and healing did not easily occur, but eventually a very good result was obtained.

FIG. 379.—Radiogram showing congenital nævus of forefinger and thumb.

Inquiry into the history showed that the patient had the big veins on the back of the hand and the blueness in the finger and thumb all his life.

Examination of the amputated finger showed the soft tissues round about the ulcer to be built up of nævoid tissue. Sections of the phalanx showed enormous blood spaces throughout. These spaces and a rarefaction of bone affecting the thumb and the forefinger are very well seen in the accompanying X-ray photograph (*Fig.* 379), which was taken by Dr. Hinton Bateman, of York.

REVIEWS AND NOTICES OF BOOKS.

Surgery of Childhood. By JOHN FRASER, M.C., M.D., Ch.M., F.R.C.S., Regius Professor of Clinical Surgery in the University of Edinburgh; Consulting Surgeon to the Royal Hospital for Sick Children, Edinburgh. In two volumes. Medium 8vo. Pp. 1150, illustrated. 1926. London: Edward Arnold & Co. 42s. net for the two volumes.

THIS is a work of great erudition. It is the only book of significance dealing with the surgical diseases of children that has been published in Great Britain during the last half century, and for that reason alone it should be given a great welcome. Judged by the highest standard as befits its ancestry it leaves little to be desired; the defects of omission are more obvious than those of commission. The author has based his writings upon his own lectures to students—who must be supplied with the conventional answers expected by examiners—and he reveals himself in addition as an ardent student of embryology. There are two influences that tend to colour and to limit to some extent the scope of his writings. The problem of the care of disease from a biological, racial, or national standpoint is how to restore to Group A the Group A individual who has been stricken by an acquired lesion; from the same standpoints the fate of the *lusus naturæ* is of little significance, and an intensive study of its embryological failure as a prologue to the carrying out of patch-work surgery destined to achieve some unhappy survivals should not be indulged in at the expense of the former group. This slight lack of balance can be appreciated best by noting the amount of space devoted to résumés of stock embryological knowledge, illustrated by a quite superfluous number of pictures of dreadful 'freaks', and the number of acquired diseases that receive no mention in this book.

In the chapter headed, "Surgery of the Chest", there is no reference at all to the surgery of the pericardium, the anterior and posterior mediastina, foreign bodies in and abscesses of the lung, bronchiectasis, lung decortication for neglected empyemata, and the breasts. These last-named organs are not possessed apparently by children, and yet they frequently present problems of minor surgical importance. Amongst other omissions under the various systems must be noted ovarian and parovarian cysts and tumours, which present the clinical pictures either of symptomless mass formation or the acute crises of twisted pedicles—gonorrhœal pyosalpinx; mesenteric cysts (1 picture only) in their various aspects of symptomless cystic swellings, as causes of acute intestinal obstruction, or as the starting-point of acute intussusceptions, and providing formidable surgical problems; acute appendicitis in a hernial sac, and primary carcinomatous, sarcomatous, and streptothrix lesions of the appendix; encysted streptococcal abscesses of the peritoneum; permanent intussusceptions masquerading as abdominal tuberculosis; intussusception and Henoch's purpura occurring simultaneously in the same patient, which constitutes a grave surgical dilemma; and ureteric calculi. A calculus in the ureter on the right side is a well-known trap for the too facile diagnostician of 'chronic appendicitis'. No mention is made of large perinephritic abscesses, and a rather unhappy reference is made to alkaptonuria, which is devoid of all surgical significance, whilst cystinuria, with all that it implies to the patient if the surgeon fails to recognize or suspect that he has removed a cystin calculus from the kidney, ureter, or bladder, is ignored.

Stenosis of the urinary meatus—*the commonest cause of* retention of urine with overflow, the cause of meatal ulcer apart from an herpetic one, and the common reason when overlooked why the operation of circumcision is held in disrepute by

some of the laity—receives only obscure notice, whilst tuberculous peritonitis and pelvic sarcomata are omitted from the list of the causes of retention with overflow.

From the osseous system with its related structures the most noteworthy omissions are: malignant diseases of the upper and lower jaw; recurrent and non-recurrent fibromata of the nasopharynx; sternoclavicular joint diseases, with those of the related sternal epiphysis of the clavicle and acute osteomyelitis of the clavicle; our old friends 'pulled elbow' and 'clicking knees', the latter apparently due to a voluntary overaction of the popliteus muscle; and, above all, torticollis with fixed neck and flaccid muscles due to the many types of dislocation and fracture of the cervical vertebræ that children inflict upon themselves so readily. A full description of this form of torticollis might well replace the space devoted to the five quite unimportant theories about the origin of congenital wry-neck, and it should have been repeated again as a most important differential diagnosis from the early stages of tuberculous disease of the cervical vertebræ.

No fewer than sixty pages are devoted to the sterile tragedies of the surgery of congenital absence of the anal canal, of encephaloceles, spina bifida, and hydrocephalus; minor head injuries—and to a lesser extent major ones—might well have encroached upon much of this space, with reference to the writings of Horsley and Gavers so well epitomized in Crisp English's Hunterian lecture of twenty-five years ago. The pages on intracranial birth hæmorrhages need to be rewritten entirely in the light of Eardley Holland's report upon the subject to the Ministry of Health, 1922.

It is surely an oversight to state that acholuric jaundice has no surgical aspect (p. 866), as splenectomy has been practised with advantage in this country for fifteen years. Equally surprising is the omission of any reference to the use of radium in the treatment of papillomata of the larynx.

These omissions, however, only detract from the essential merits of the book inasmuch as the distinguished author's views upon these lesions are not yet available for the service of the community. The opening chapters upon general principles should be studied by everyone; and those clinicians who have practised for twenty years a rigid abstention from starvation and purgation as preliminaries to operative treatment, combined with a heaping up of the patients' reserves of O_2 carriers by the pre- and post-operative administration of glucose, will be refreshed to find their practice receiving the sanction of such an authoritative text-book.

Tuberculous and non-tuberculous diseases and injuries of bones and joints are dealt with in admirable detail which fills nearly the whole of Volume I. The lesson can be found permeating all the writings that nothing but the most meticulous attention to detail can be tolerated when surgical measures are used in the treatment of disease. The author's own operation of laminotomy for decompression of the spinal cord is most ingenious and worthy of an extensive trial.

In Volume II the chapters on the surgery of the abdomen should appeal to all readers; here they will relearn the necessity of applying in detail the general principles already expounded so lucidly in Volume I. The problems of hernia, glands in the neck, and deformities, both congenital and acquired, are set out at full length and clearly explained.

With regard to typographical errors, anomalies is spelt 'amanalies', p. 987, and throughout the book the name of Fairbank is misspelt consistently as 'Fairbanks'. In the addendum it might be noted that Pexuloid is the non-inflammable form of celluloid invented by Mr. T. W. Peck, F.C.S., in conjunction with the late Dr. F. E. Batten, when the latter invented his splints and casings for the treatment of palsies in children.

To sum up, the work is not encyclopædic, as might have been expected from its issue in two volumes, and the admirable clinical lessons contained therein are apt to be overshadowed in parts by descriptions of laboratory test-tube reactions of ephemeral value, of unimportant theories, and of recapitulations of embryology that ought to be taught and learned elsewhere. Nevertheless, it has assumed at once the position of the standard text-book upon the surgery of childhood, and there are no caretakers of the sick who can afford to be unfamiliar with its contents. It is a work of great expectations, of few disappointments, and of the brightest hope for many editions in the future.

Mesenteric Vascular Occlusion. By A. J. Cokkinis, M.B., B.S., F.R.C.S., Surgical Registrar, London Lock Hospital. Demy 8vo. Pp. 159 + xii, with 5 illustrations. 1926. London: Baillière, Tindall & Cox. 10s. 6d. net.

This thesis was prepared with the object of drawing attention to a subject which, in the opinion of the author has been "unjustly neglected in this country". It is based on certain anatomical researches and upon the clinical and post-mortem records of 76 cases in which occlusion of the mesenteric vessels had occurred.

The description of the anatomical arrangement of the mesenteric vessels is supplemented by an account of injection experiments carried out on the cadaver, which showed that occlusion only of the vasa recta or terminal arcades in the mesentery cut off the blood-supply of the gut. However, ligature of the main trunk below the origin of the middle colic artery cuts off the injection material from half the small intestine. It was found that there were weak spots in the collateral circulation at the upper and lower ends of the territory supplied by the superior mesenteric vessels.

As a result of disease the arteries or veins in the mesentery may be occluded, the former usually by embolism, the latter by thrombosis secondary to portal obstruction or sepsis in the portal area. An extreme degree of venous obstruction may take place without infarction of the gut.

The clinical manifestations are described, the picture being 'made up' from case records so as to give the 'typical' signs and symptoms which should indicate mesenteric occlusion. The picture presented is a clear one which should make the diagnosis relatively simple, yet a careful study of the author's 76 cases will show that this is not so in practice. It is argued that a carefully taken clinical history and a thorough examination "should in a large proportion of cases enable a correct diagnosis to be made". In the 76 cases the diagnosis was made and confirmed 6 times, and twice on apparently very slender foundations. It is possibly true, as the author suggests, that as the condition becomes better known the diagnosis may be made more frequently.

The treatment of the cases in which infarction of the gut has occurred is early excision of the affected portion. Out of 12 cases in this series in which this treatment was adopted 5 survived. When treatment was delayed death was inevitable —32 in the present series were operated on, resection was impossible, and they all died.

There are, however, many cases of complete obstruction of the portal vein without infarction of the gut; and so many of arterial embolism occurring in the course of a disease which is in itself inevitably fatal that we cannot share the author's optimism when he opines that "the time is not far distant when the prognosis of mesenteric occlusion will be considerably more hopeful than it has been in the past".

The House Surgeon's Vade-Mecum. By Russell Howard, C.B.E., M.S. (Lond.), F.R.C.S. (Eng.), Member of Court of Examiners, Royal College of Surgeons, Surgeon to the London Hospital; and Alan Perry, M.B., M.S. (Lond.), F.R.C.S. (Eng.), Assistant Surgeon to the London Hospital. Second edition, revised and enlarged. Crown 8vo. Pp. 507 + viii, illustrated. 1926. London: Edward Arnold & Co. 12s. 6d. net.

This second edition is an enlargement of the first, and the authors have endeavoured to bring the book up to date by incorporating notes on modern methods used in the management of surgical cases. Such will be found especially in the sections dealing with the treatment of infected wounds, the treatment of shock, the researches into acute infections of the hand, the investigation of renal cases by pyeloradiography, and the treatment of fractures. The chapter on anæsthetics has been revised by Dr. Ashley Daly.

From the point of view of the house surgeon the chapters on inflammation of joints and those on fractures, with the details of after-treatment for special joints and special fractures, are perhaps the most useful in the book. Excellent photographs of patients under treatment by means of various splinting appliances form a noteworthy improvement in the description of fractures.

There are certain points which appear to call for further improvement in future editions. For example, the description of the technique of blood transfusion is bad, especially in that the method entails considerable manipulation of, and damage to, the donor's vein—a matter of no little importance so long as the 'voluntary system' of obtaining donors holds sway. In the account of skin-grafting it is stated that the area of skin from which the grafts are to be taken must " be prepared in the usual way for an aseptic operation " (with antiseptics). The chapter on amputations still contains a large number of operations which are never performed nowadays, and in describing Syme's amputation it is recommended that " drainage may be provided for by making a button-hole in the heel flap ". It is doubtful, too, whether a house surgeon ever wants to know the five reasons for passing a catheter.

These points are, however, of small importance as compared with the vast amount of information the book contains. It must be admitted that a house surgeon who is left rather 'on his own' by his chief will not find all the direction he requires for the management of his cases before and after operation, but that is more than can be expected in a book of this size.

The Fundamentals of the Art of Surgery. By JOHN H. WATSON, M.B. B.S., F.R.C.S., Surgeon to the Victoria Hospital, Burnley. Demy 8vo. Pp. 349, illustrated. 1926. London: William Heinemann. 17s. 6d. net.

THERE are books on general surgery, books on special surgery, books on surgical technique, treatises dealing with emergency work, and manuals of minor surgery. The present volume cannot be placed in any of these categories. What claim it has for consideration—and it is a considerable claim—is based upon the appeal it makes to the man assuming the responsibilities of an actively surgical career, that he should take the widest possible view of his work. The author has this mission to carry out, and we think he succeeds. The fascination of technique, especially during the period of its acquisition, is apt to overshadow the other equally essential elements of the surgeon's art. The reader who digests the opening chapters of this book is not likely to fall into this error. This initial part is a collection of essays upon such subjects as the art of surgery, surgical efficiency, surgical judgement. They are pleasant reading, full of good advice and the wisdom of experience. The rest of the book is a miscellaneous collection of chapters upon the general conduct of operations and post-operative care. Much of this information can be obtained in a fuller and more systematic fashion in existing text-books, but here we get the recommendations, technical arrangements, and devices found to be the best in the practice of a busy surgeon in a large provincial town; therein lies its value. Though his customs may differ from those of the author, no surgeon can lay this book down without the feeling that he has acquired something of worth from its perusal.

A Handbook of Renal Surgery. By F. McG. LOUGHNANE, F.R.C.S., Hon. Surgeon, St. Mary's Hospital, Plaistow; Hon. Assistant Surgeon, All Saints' Hospital for Genito-urinary Diseases. Demy 8vo. Pp. 210 + xiv, illustrated. 1926. London: Longmans, Green & Co., Ltd. 10s. 6d. net.

THE author states in his preface that " this book is intended for the use of general practitioners and students, and has been written with the aim of presenting in as concise a manner as possible a complete up-to-date statement of practical renal surgery ". We congratulate the author, for he has produced what he set out to do; that the book is concise is shown by the fact that he has surveyed the field of kidney surgery in 210 pages, many of which are occupied by illustrations, and that it is up-to-date is proved by the large number of reproductions of pyelograms, most of which are excellent. So much attention is paid to the pathology and diagnosis of renal disease that the author has had to cut down the accounts of operative details to a minimum; perhaps he did this of malice aforethought, as

he did not consider students and practitioners to be fitted to grapple with operative details.

The defect of all such short and comprehensive text-books is that the author, in order to be concise, has to appear dogmatic. Several of the statements in this book are unusual, and one would very much like to read the experience that has led the author to make them; to quote just one: "In cases of enlarged prostate, where the blood-urea is high and indigo-carmine elimination delayed, the blood-urea returns to normal after a supra-pubic cystostomy long before the indigo test is satisfactory, but success in the second stage of the operation depends upon the obtaining of a satisfactory indigo test, rather than upon the return of the blood-urea to normal". This and numerous similar statements are given without being supported by any proof, and leave the reader incredulous.

The book is excellently printed and the illustrations are uniformly good; occasionally the English appears to us to be slovenly, as in the following statement: "The relations of the muscular surface are, viz. the transverse processes of the 12th dorsal", etc., where the 'viz.' seems to be superfluous; again, it is stated that the onset of pyelitis may be attended with 'low' rigors, and the reader is left puzzled as to what exactly is meant. There is, however, no doubt what the author means when he says that women are more liable to infection with the colon bacillus than men "owing to the semi-cloacal condition of their sexual anatomy", but it does seem rather a horrid way of putting it.

The Secretion of the Urine. By ARTHUR R. CUSHNY, M.A., M.D., LL.D., F.R.S. Second edition. Demy 8vo. Pp. 288 + xii, illustrated. 1926. London: Longmans, Green & Co. Ltd. 16s.

THIS book is one of the series of Monographs on Physiology, edited by Ernest H. Starling; its author was the late Professor of Pharmacology in the University of Edinburgh. As one would expect from the scientific eminence of the writer, the volume represents an earnest and most conscientious attempt to present the truth and to discriminate between what is fact and what is only theory—not an easy task, we fancy, in this particular subject.

The enormous amount of work involved in the composition of the book is shown by the bibliography of no fewer than 593 references; the author confesses that his "patience was sorely tried by some papers in which the depth bore no proportion to the length". Such a very large amount of information is compressed into the 288 pages of this monograph that the reader's attention has to be kept up to concert pitch to avoid missing the threads of the argument; but we are quite sure that the labour is not wasted, and that this will be a standard work on the subject for many years and will be invaluable as a work of reference.

It would need a physiologist to give an intelligent and sympathetic criticism of the author's long discussion on the various theories which are current on the mechanism of urinary secretion, but we gather that the late Professor Cushny was all for mechanical as against vitalistic explanations; it is no less certain that he found some serious stumbling-blocks in his attempt to eliminate the vitalistic element. Although much of the book is devoted to discussions of theories of urinary excretion which are of interest pre-eminently to the physiologist, there are numerous sections which will be of great interest to the surgeon, and we propose to refer to some of these.

On page 12 will be found an admirable summary of the voluminous literature on the subject of the influence of the renal nerves on secretion. Excellent sections are devoted to the excretion of dyes by the kidney and to the effects of complete and partial closure of the ureters. Of quite special importance is the statement that "when the blood is diluted by the intravenous injection of urea or salts, the kidney may continue to secrete though the blood-pressure is far below the point at which it would cease with normal composition of the blood"; this is encouraging in view of the occasional occurrence of anuria after prostatectomy. We should like also to draw attention to the remarks on the effect of closure of the renal artery

and on constriction and closure of the renal vein. The chapter on albuminuria and the excretion of bacteria by the kidney is full of interest to the surgeon. The last chapter is entitled "Notes on Nephritis and Other Renal Disorders" and contains a section on tests of renal efficiency; it is well worth reading carefully.

Altogether an admirable book which we can warmly commend to our readers.

Die Chirurgie: A System of Surgery. Edited by Professor KIRSCHNER (Königsberg) and PROFESSOR O. NORDMANN (Berlin). To be completed in six volumes. Fasc. 9, Vol. V. Imperial 8vo. Pp. 360, with 68 illustrations in the text and 39 coloured plates. 1926. Berlin: Urban & Schwarzenberg. M. 26.

THIS section of the big new German text-book on surgery is devoted to the abdomen, the abdominal wall, external hernia, peritoneum, and appendix.

Professor Müller, of Rostock, writes about the surgery of the abdominal wall. Anatomy, physiology, and development are described in some detail. Traumatic and inflammatory affections and new growths are dealt with before discussing the defects and their treatment. The utilization of the sartorius muscle to make good a defect of the rectus abdominis is described and figured. The chapter terminates with a consideration of the plastic surgery of pendulous belly.

The chapter on external hernias is by Dr. Eggers, of Rostock. Various theories of the origin of hernias are mentioned, without definite adhesion to one. Very clear diagrams and coloured figures illustrate the different types of strangulated hernias and the complications of taxis. Bassini's operation is well described and illustrated and the chief modifications are mentioned, but one looks in vain for special discussion of the treatment of direct inguinal hernias, or for any mention of the use of filigrees or of fascial grafting. The unusual forms of hernia are fully described. The mention of trusses is very brief and unaccompanied by any illustrations, nor is there any reference to the varieties of trusses suitable for special types of hernia.

Dr. J. Petermann, of Berlin, gives the chapter on the peritoneum and omentum, and his general description of peritonitis, with the clear illustrations and extensive literature references, affords an excellent exposition of the subject.

The concluding chapter of this section is devoted to the appendix and its diseases, and is by Professors Läwen and Burckhardt, of Marburg. The gross and minute anatomy are well described and illustrated. In the section on the etiology of appendicitis one is disappointed to find that it is assumed that the disease has always existed, and that there is practically no discussion on the mysterious prevalence and increase of the condition since the beginning of the present century. The clinical aspect of the subject is very carefully and accurately described and the coloured figures of pathological conditions are of high artistic merit. The discussion of the so-called chronic appendicitis and its differentiation from other causes of abdominal pain is especially valuable. In dealing with the rarer diseases of the appendix, the incidence of parasitic infection is perhaps unduly stressed, whilst that of actinomycosis hardly receives the attention or illustration that its importance deserves.

Die Chirurgie: A System of Surgery. Edited by Professors KIRSCHNER and NORDMANN. Fasc. 10, Vol. V. Imperial 8vo. Pp. 319, with 91 partly coloured illustrations in the text and 10 coloured plates. 1926. Berlin: Urban & Schwarzenberg. M. 21.

THIS section deals exclusively with diseases of the stomach and duodenum. It is written by Professors Guleke, Nieden, and Smidt from Jena, and, although illustrated by a number of excellent coloured figures, it is somewhat disappointing in its rather partial and uneven treatment of the subject. The first portion of the monograph deals with general principles, anatomy, physiology, methods of examination, and operative technique. Of this, the description of the X-ray appearances of the normal and diseased organs is full and valuable, but the chemical examination is very meagre and not worthy of any classical book of reference. All the standard operations are well described and illustrated, but the description is rather that of formal procedures which might be carried out in the dissecting-room than of actual operations on diseased tissues.

The chapters dealing with ulcer and cancer are the best in the monograph. Possibly the diagnosis of gastric ulcer might be more fully discussed, especially in relation to functional conditions such as visceroptosis. But the descriptions of symptoms, complications, and treatment are full, clear, and beautifully illustrated. Our main criticism of this part is that the affections of the duodenum are not sufficiently differentiated from those of the stomach.

Die Chirurgie: A System of Surgery. Edited by Professors KIRSCHNER and NORDMANN. Fasc. 11, Vol. V. Imperial 8vo. Pp. 163, with 77 illustrations, some coloured, in the text and 7 coloured plates. 1926. Berlin: Urban & Schwarzenberg. M. 10.

THIS section is concerned only with the rectum and anus, and is written by Professor Tietze, of Breslau, and Dr. Reichle, of Stuttgart. It opens with a clear and well illustrated account of the anatomy of the parts and the various congenital malformations. Prolapse of the rectum is fully described and discussed, and a variety of operations are given in detail. Inflammatory affections, and simple and specific ulcers are fully dealt with, but the descriptions of the different varieties of fistula occupy only a small space with a single figure in addition to two coloured microscopical sections.

The section on hæmorrhoids is very much on ordinary lines, ligature and excision being described as the routine method of treatment, whilst injection methods and Whitehead's operation are also mentioned. Malignant disease forms the subject of the last part of the monograph. The sacral method of excision chiefly associated with Kraske's name is described at some length as the routine radical operation. The abdomino-perineal method, though mentioned, is not given the importance which it deserves, nor is it illustrated.

Die Chirurgie: A System of Surgery. Edited by Professors KIRSCHNER and NORDMANN. Fasc. 8, Vol. IV, *Die Chirurgie des Ohres.* By Professor Dr. ARTHUR BLOHMKE. Imperial 8vo. Pp. 277, with 75 illustrations in the text and 4 coloured plates. Berlin: Urban & Schwarzenberg. M. 16.

THIS eighth part of the fourth volume of the series deals with the surgery of the ear. Professor Blohmke does not depart from the usually accepted arrangement; he deals first with the anatomy, physiology, and histology of the subject in an exceedingly lucid manner. There are no unnecessary details to leave a confused impression on the mind; throughout there is never a suggestion of padding.

The author recommends the rough and ready caloric reaction of Brühl. We have found that of Kobrak more useful and delicate, particularly when the difference between the two labyrinths is slight. The author goes into some detail about local anæsthesia in ear operations, but is not enthusiastic, a viewpoint which possibly is shared by his colleagues in this country. He nevertheless favours Von Eicken's method of inducing local anæsthesia of the external auditory meatus for furunculosis. The descriptions of the actual operations are unusually clear and in a class by themselves. These are no mere transcriptions from a previous text-book, but obviously the result of the rich experience of an exceedingly practical man. An admirable discretion is shown in the selection of operative methods: from the staggering number of operations for eversion of the auricle only two are selected—those of Gersung and Passow. One cannot but agree with the author when he says that Cushing's operation for eighth-nerve or cerebellopontine-angle tumours has put all other methods "completely in the shade". He omits describing other methods. The hints of how to find the antrum in a sclerotic mastoid are exceedingly valuable. He recommends the approach from above downwards, even to exposing a small portion of the dura mater of the middle fossa as a guide. The radical, the Schwartze, and the labyrinthine operation of Neumann Janson receive adequate treatment from the practical point of view. It is unfortunate that the operation which may entirely replace the Schwartze, and also to a certain extent the radical, and which has particular regard to the saving of hearing, is entirely omitted—I refer to the conservative operation of Heath. The book concludes with a detailed section of the intracranial complications and their treatment.

We do not recollect reading a text-book with more pleasure or profit. It seems

a pity that otologists are forced to buy the whole of the six volumes in order to obtain this one book—the publishers state quite definitely, however, that it is not available separately. There is no index. We are told a collective index will be issued with the last volume of the series. Professor Blohmke is to be congratulated on having produced a comprehensive work that is not ponderous, indeed a *rara avis* with our German colleagues. With a little more generosity in the way of illustrations—there are only 79—and provided it is obtainable separately with an index, it should take its place among the books of reference in operative otology.

Lehrbuch der topographischen Anatomie. By JOHN BLUMBERG, Lecturer in Surgical Anatomy at the University of Dorpat in Esthonia. Royal 8vo. Pp. 486, with 152 illustrations, most of which are in colour. 1926. Berlin and Vienna: Urban & Schwarzenberg. M. 21; bound, M. 24.

THIS is without doubt one of the finest works on the subject of regional anatomy that has been published in recent years. The text is full, clear, and accurate, whilst the numerous large illustrations are models of artistic skill and anatomical accuracy. A very large number of these figures are taken from unusual points of view or from special dissections, and in this way show up the relationships of the various structures in a striking manner. The book is divided into eight chapters, which deal with the chest, abdomen, pelvis, back, lower extremity, head, neck, and upper extremity.

We have not been able to find any inaccuracies in text or figures, but a curious want of proportion occurs in several of the arm illustrations (*Figs.* 137, 144, 145), in which the ulnar collateral artery (or, as we should call it, the inferior profunda) is depicted as being of almost the same size as the lower part of the main brachial artery.

We certainly should welcome an English translation of this work if it were only for the sake of the beautiful figures.

Die operative Technik des Tierexperimentes. By H. F. O. HABERLAND, Professor of Surgery in Cologne University. Royal 8vo. Pp. 336, with 300 illustrations. Berlin: Julius Springer. M. 28.50; bound, M. 30.

THE worker who is commencing an experimental study in the laboratory is faced immediately by many problems connected with the anatomy, mode of handling, anæsthetizing, and care of the animals with which he proposes to work. As a rule he must serve an apprenticeship in laboratory technique before he can proceed to any fruitful piece of research. Professor Haberland has performed a useful service in outlining in concise form the essentials of the anatomy and the methods of handling the various animals employed in the experimental laboratory, and in giving a brief but comprehensive résumé of the operative methods employed in investigations on the various systems of the body. The methods described are simple and in some cases even crude, and are designed to allow of experimental work with the minimum of assistance.

Whilst much recent experimental work is not even referred to and the methods employed in other countries are largely ignored, the author has made a distinct contribution to experimental surgery. All laboratory workers will find some useful hints by reference to this work, which is commendably concise, and freely and well illustrated.

La Pratique chirurgicale illustrée. By VICTOR PAUCHET. Fasc. 9. Royal 8vo. Pp. 260, with 246 illustrations by S. DUPRET. 1926. Paris: Gaston Doin et Cie. Fr. 40. [7s. 6d.]

WHEN completed Victor Pauchet's book on operative surgery will comprise twenty volumes. In the ninth volume, which is now under review, Pauchet returns to his favourite subject—duodenal ulcer—and as in previous volumes the numerous and lucid illustrations of Monsieur S. Dupret render the text almost superfluous. Gastrectomy after failure to cure with gastro-enterostomy and gastro-jejuno-colic fistula

are especially considered. Resection *en masse* of the distal half of the stomach with the proximal half of the colon and a portion of the jejunum is advocated for the latter condition. No fewer than three anastomoses are involved in this method, together with the establishment of a temporary fistula for the terminal ileum and the distal colon—a truly heroic procedure.

A method of abdomino-perineal excision of the rectum with preservation of the sphincters is described. This is the operation which was employed for a short time some twenty years ago in London and styled 'abdomino-anal'; it was abandoned in favour of the abdomino-perineal operation with colostomy. Some disadvantages of the method Pauchet describes may be cited: It is less radical as regards the lymphatics; it often results in poor control; and there is considerable danger of sloughing of the lower end of the colon from deficient blood-supply. The abdomino-perineal operation with colostomy is also described. Pauchet carries out the perineal stage by dissecting from below upward instead of from above downwards. The latter method is usually adopted in this country and is certainly quicker. The closure of fæcal and biliary fistulæ and anterior nephrectomy are well described.

Operations for hallux valgus and great mammary hypertrophy (by Pierre Mornard) are included in the volume. For the latter condition an ingenious, if somewhat elaborate, method of mastopexy is described. If it can be carried out with success in lieu of amputation, it will be welcomed by all surgeons.

Throughout the volume every operative stage is clearly portrayed, a most valuable asset in any work on operative surgery.

Traitement des Cancers du Maxillaire inférieur. By Dr. RAYMOND BERNARD, ancien interne des Hôpitaux de Paris. Pp. 116. 1926. Paris: Gaston Doin. Fr. 18.

THIS is a monograph on cancers of the tongue, floor of the mouth, cheek, or tonsil, which extend to and invade the lower jaw. It is a grouping of cases which is justified from the fact that the osseous lesion dominates the situation. An account of the clinical features and pathology is given first, and stress is laid upon the fact that extension through the inferior maxilla is very slow, especially in the lower dense part of the jaw, so that since invasion takes place from the gum, it is nearly always permissible to retain the inferior margin of the mandible. Successively, treatment by radium, radium combined with surgery, and surgery alone are given. Treatment by radium alone is condemned because of the sepsis which results from the inevitable necrosis of bone, and the outcome of the combined method is little better. Much more satisfactory results have been obtained by pure surgical measures. Though the mortality is very high (43 per cent), yet amongst the survivors 43 per cent remain cured permanently. The author believes in an extensive operation for the removal of the lymphatic glands in the neck, and recommends removal of the sternomastoid with a clearing of both posterior and anterior triangles.

L'Arthroplastie du Genou. By Dr. C. H. CHEVALLIER, Faculty of Medicine of Paris. Royal 8vo. Pp. 152, with 7 plates. 1926. Paris: Masson et Cie. 2s. net.

THIS little monograph should be read by all general surgeons. As many as 444 cases have been recorded, with a large number of failures, but amongst them there stand out Professor Putti's 63 operations with only 1 death, 4 failures, 5 poor results, and 52 successes (83·87 per cent) giving a mean mobility of 57°. If one surgeon by proper selection of cases—the average age is 26 years, and no tuberculous cases are included—and by a well-developed technique can obtain such results, the operation deserves, as the author says, to enter into surgical practice. The procedure here described and figured varies but little from that of Putti: the essence of it is the transplantation of one very long wide strip of fascia lata, which gives continuous covering to the bone ends, the soft parts at the back of the 'joint', the posterior aspect of the patella, and the lengthened quadriceps expansion. The technique is

not difficult; the graft lives well and controls the formation of new bone. Difficulties may arise from blood-oozing after closure of the soft parts and removal of the tourniquet. If this trouble be surmounted, a new membrane of capsule type forms about the bone-ends, and it is stated that the new joint is less susceptible to blood-borne infections than a normal articulation.

Technique des Prélèvements et des Biopsies dans la Pratique clinique. By ROBERT DUPONT, ROGER LEROUX, and JEAN DALSACE. Crown 8vo. Pp. 142, with 50 illustrations. 1926. Paris: Masson et Cie. 2s.

THIS small book is intended to give precise directions for the obtaining and preparation of material from the patient for pathological examination and report. It includes examination of the blood, urine, cerebrospinal fluid, gastric contents, stools, milk, spermatic fluid, pus and serous fluids, and morbid tissues. It is very concise and practical, and illustrated by clear line drawings.

Chirurgie de L'Estomac. By HENRI HARTMANN, Professeur de Clinique chirurgicale, Chirurgien de l'Hôtel-Dieu; with the collaboration of NICOLAE BARBILIAN, R. BENSAUDE, CHABRUT-ASTAIX, DE POLIAKOFF, and ROBERT TARJAN. Part I. Imperial 8vo. Pp. 336, with 115 illustrations. 1926. Paris: Masson et Cie. 6s. 8d.

PROFESSOR HARTMANN has written a book which will become a work of reference, and is particularly valuable as it is a faithful record of the experiences of a master surgeon, extending over many years. This part treats of methods of examination of the stomach, perforated ulcers of the stomach and duodenum, the technique of operations upon the stomach, gastrojejunostomy in all its aspects, the results of operations upon cancer of the stomach, the changes in the gastric chemistry brought about by operations on the stomach, gastrojejunal ulcer, and benign new growths. Its pages are full of interest to anybody engaged in this branch of surgical work, and all subjects have been discussed with admirable judgement. Professor Hartmann has employed the gastroscope, and he uses one of his own pattern which is passed over a wire guide. He thinks gastroscopy has a definite place, but it should be the last method of examination before resorting to a laparotomy, which it will sometimes obviate. He believes that it will have a great future.

The section on perforated ulcers is very complete and contains most useful information. For instance, we learn that the cures after draining a perigastric abscess resulting from a perforated ulcer amount to 42·8 per cent. This is a very grave condition, but these figures show an unexpected recovery-rate. On the question of shock in perforation about which there is some discussion, the author states that cases occur which die in a few hours from shock alone. He admits they are rare, but maintains that they exist. He does not believe it is wise to wait for the stage of shock to pass off, however, before operating. His recommendation is to operate as early as possible, as it is important to prevent infection of the peritoneal cavity. The mortality in perforated ulcer, according to his statistics, was 29 per cent for fourteen years, but only 15 per cent for the last fifteen years. He stresses the importance of early intervention. He discusses the question of gastrectomy for perforated ulcer, and concludes that it has twice as great a mortality as simple suture alone or suture combined with gastro-enterostomy, of which the mortalities are the same. Only 10 per cent of patients who have had simple suture required a subsequent gastrojejunostomy. He thinks the end-results of gastro-enterostomy plus suture are uniformly good. The late results, however, seem to depend to some extent on the nature of the ulcer, whether it was an acute or chronic lesion.

In the section on technique all operative methods are fully discussed, including such rare operations as resection of the cardia and total excision of the stomach. Excision of the lesser curvature combined with gastro-enterostomy has given good results. The author has never seen suppuration or bad result follow the removal of a slice of the pancreas in performing gastrectomy for carcinoma. The mechanics

and physiology of gastro-enterostomy are well set forth, and an account is included of the author's investigations into the influence of the situation of the anastomotic opening upon the path of exit of the chyme.

As many as 843 gastro-enterostomies are reported which were operated upon by Professor Hartmann and his associates. The mortality was 26 per cent in cancer cases and 10 per cent when the operation was done for benign affections; 2·5 per cent of the deaths were due to lung complications in ulcer and 5 per cent in cancer. There are reports of the other complications which have occurred and a discussion on the treatment of them.

In recording the results of gastrojejunostomy for ulcer Professor Hartmann has been surprised to find how well the ulcers of the lesser curvature have done with this simple operation. In the account of gastrojejunal ulcer he states that the ideal operation for its cure is to undo the anastomosis, resect the stomach, and finish by a terminal junction. The section on cancer of the stomach, where 100 cases are reviewed, gives a surprising recovery-rate of 30 per cent well after three years.

This book can be recommended to all abdominal surgeons, for it seems to be a very fair statement of the surgery in competent hands.

La Cystographie: Etude radiologique de la Vessie normale et pathologique. By Drs. H. BLANC and M. NEGRO. Royal 8vo. Pp. 192, with 108 illustrations. 1926. Paris: Masson et Cie. 6s. 8d. net.

THIS monograph gives a full and satisfactory account of cystography, which may be defined as the study of the bladder by taking X-ray photographs of the organ after it has been filled with a solution opaque to the X rays.

The authors have carried out the extensive investigations which formed the basis of this work in the Service Civiale of the Lariboisière Hospital; the preface has been written by Dr. G. Marion, the head of the department. They begin by giving a short history of cystography and a full description of the technique which they have adopted; we note that they come to the conclusion that the most convenient medium for distending the bladder is sodium bromide, which they use in strengths never exceeding 10 per cent. Numerous diagrams are given to show the position of the patient and of the X-ray tubes.

After devoting some time to the discussion of photographs illustrating the normal bladder in its various degrees of distention, the authors show a wonderful series of photographs of diverticula of the bladder; they think that cystography is of great importance in this condition. Numerous prints of cystographs of cases of tumour of the bladder indicate what a considerable aid these may be when the vesical cavity is so encroached on that cystoscopy is extremely difficult. A most interesting chapter is that devoted to patency of the ureteral orifices, and another equally interesting section is that in which illustrations of congenital abnormalities are given.

The results of cystography in the diagnosis of enlargement of the prostate are frankly disappointing, as the authors indeed point out. Pneumocystography is discussed, but the authors do not favour this method of investigation.

The skiagrams are beautifully reproduced, and we have no hesitation in recommending this book to our readers, especially to those who are interested in urinary surgery.

Chirurgie du Sympathique: Chirurgie du Tonus musculaire. By P. WERTHEIMER and A. BONNIOT, with a Preface by Dr. LERICHE. Royal 8vo. Pp. 135, with 21 illustrations. 1926. Paris: Masson et Cie. Fr. 22.

A BELATED contribution to the overburdened subject of sympathetic ramisection for spastic states. The authors commence by a consideration of the anatomy of the sympathetic system, beautifully illustrated by original plates. The physiology of muscle tone and the rôle of the sympathetic is then outlined. The authors frankly avoid the main issues of controversy in the theoretical and experimental aspects,

but prefer to take their stand by the results obtained after operation in diseases characterized by spasticity.

After a detailed consideration of the operative technique for cervical and lumbar ramisection, the authors quote detailed results from a case of Adson's, two of Bruning's, and seven of their own. They emphasize the innocuousness of the operation (89 ramisections without a death) and the absence of ill-effects such as wasting of muscles or visceral disorders. A degree of ptosis and enophthalmos is usual after division of the cervical sympathetic, but is transitory; reference is also made to the appearance of flushing over the corresponding limb. The effect on muscle tonus has been inconstant and slight; in general terms, rigidity due to vascular lesions and to spinal scleroses is less amenable than when resulting from cortical injury or birth palsies. The authors repeatedly state that the applicability of this operation is still *sub judice*, and that time alone will delimit its sphere of usefulness.

In detailing the clinical condition before and after operation the conclusions are severely invalidated by incomplete neurological investigations. The quantitative estimation of hypertonus is still unsatisfactory, and inaccurate mechanical measurement of the degree of spasticity can only be compensated by the most painstaking examination of the central nervous system by competent authorities at repeated sittings. Such data are wanting in the cases reported by Wertheimer and Bonniot. Another important point which must be borne in mind is the prematurity of the post-operative publications; not one of the authors' cases was reported upon at a period longer than thirteen weeks after the operation. In view of the acknowledged transitory nature of the Claud-Bernard-Horner syndrome after cervical ramisection, there is no reason for expecting the occasional slight diminution in tonus to be other than temporary. It is possible that the vasomotor instability immediately following section of the sympathetic is in part responsible for an increased suppleness in the corresponding limbs, but here again permanent results are scarcely to be expected. Lastly, the psychology of the patient must also be realized, and one must be scrupulous in ruling out mere removal of functional disability which had been engrafted upon a genuine organic substratum in cases of chronic nervous disease.

The volume concludes with a bibliography, in which one or two important monographs do not appear.

Handbook of Diseases of the Rectum. By Louis J. Hirschman, M.D., F.A.C.S. Fourth edition, revised and rewritten. Medium 8vo. Pp. 403, with 252 illustrations and 5 coloured plates. 1926. London: Henry Kimpton. 30s. net.

It speaks highly for the popularity of this book that it has reached a fourth edition since its publication in 1909.

The opening chapter contains a concise account of the essential anatomy of the parts concerned. When speaking of the lymphatic system of the rectum there is some ambiguity in the description of the lymphatic glands situated between the rectum and the sacrum, which the author refers to as the postrectal glands. So far as we are aware there are two distinct sets of glands in this locality—namely, the glands contained in the terminal portion of the pelvic colon (commonly called retrorectal glands), which are invariably involved in cancer of the rectum, and the presacral glands, situated along the course of the lateral sacral vessels, which are involved during the later stages of that disease and only when the growth has extended beyond the limits of the fascia propria. Since both these glandular groups are found between the rectum and the sacrum it is important that a distinction should be made between them.

Chapter 2 deals with symptomatology. The author gives very sound advice when he says that rectal hæmorrhage, no matter how slight, should never be taken for granted as diagnostic of hæmorrhoids or any other disease, but should call for a complete examination. Chapter 3 is devoted to a description of the various methods employed when making an examination of the patient. Anoscopy, proctoscopy, and sigmoidoscopy are all carefully described, and many useful hints with

regard to the use of the instruments are given. Chapter 4 deals extensively with local anæsthesia and sacral anæsthesia. The technique of these procedures is carefully described. When speaking of sacral anæsthesia no mention is made, however, of the advisability of making sure that the theca has not been penetrated by the needle before introducing the solution into the sacral canal. Chapter 5 discusses the limitations of local anæsthesia and the general contra-indications to its use.

Constipation and obstipation are dealt with at considerable length in Chapter 6, etiological factors being discussed and various methods of treatment described. Among the latter is the author's method of direct stimulation of the atonic sigmoid and rectum by means of mechanical dilatation. For this purpose he makes use of a specially-shaped rubber bag provided with a stem which is slipped over the distal end of a Wales's bougie. Compressed air of low pressure is allowed to enter the bag, thus slowly producing distention to any required extent. The author's operation for rectal valvotomy is also given in detail.

Chapter 8 is concerned with that peculiarly distressing complaint pruritus ani. The possible etiology is fully discussed and the various operative procedures that have been suggested from time to time as curative receive careful consideration. The author's technique for his modification of Ball's operation is described in detail. Anal fissure and ulcer are fully considered in Chapter 9. As one of the causes of fissure the author mentions the tearing-down of an anal valve. We do not agree with this, as we consider that a true fissure and a torn-down anal valve are totally distinct things, as evidenced by their shape; the fissure being pear-shaped, whereas the margins of the lesion produced by a torn-down valve are parallel to one another. When discussing surgical treatment preference is given to excision over the much more simple expedient of incision.

The various abscesses met with in the ano-rectal region are described in Chapter 10 and the method of operating applicable to each is given in detail.

Chapter 11 is devoted to the subject of fistula, but this is unfortunately incomplete because only those varieties that are amenable to treatment under local anæsthesia are discussed. The classification of fistulæ is the one usually adopted, and is, in our opinion, insufficient, as it presumes that all fistulæ are of the same type. The author quite correctly states that the type of a fistula depends upon the location of the abscess which preceded it, but he does not carry this observation into effect when he classifies them. We consider that the failure to realize that fistulæ differ greatly in type is the principal cause of the disastrous effects of operative interference in some cases.

Hæmorrhoids are discussed in Chapter 12, the various operative procedures that are usually employed being set forth in detail. The remainder of the book does not call for much comment, and is concerned with polyposis, dysentery, and prolapse. We are surprised to find that the important subject of cancer is dismissed in a cursory notice in the chapter on local anæsthesia. The pathology of the spread of cancer from the rectum is not even mentioned, nor are the operative measures referred to that have been devised with a view to the complete eradication of the disease. We consider that this is a grave omission in a work that purports to be a guide to the treatment of diseases of the rectum.

What it Feels Like: Letters from a Doctor out East to a Colleague at Home. By 'Dr. ROBIN', M.A. (Oxon), M.R.C.P. (Lond.). With an Introduction by Sir HUMPHREY ROLLESTON, Past President of the Royal College of Physicians. Crown 8vo. Pp. 78. Paper covers. 1926. Student Christian Movement. 2s. net.

THIS little collection of letters from a medical missionary in China to a friend in England purports to answer the question, so often asked concerning missionary life: "What does it feel like to be a missionary?" The author, who calls himself Dr. Robin, and who studied at Oxford under Sir William Osler, answers this question in a manner so enthusiastic that to the average reader it may seem a little exuberant. Despite his obviously sincere devotion to a noble cause, it is difficult to feel that he has not somewhat overworked such adjectives as 'wonderful' and 'fascinating'.

The book contains, however, much that is interesting, notably the description of a morning among Chinese out-patients, and the accounts of work in famine and war areas. Dr. Robin is clearly a keen admirer of Chinese character and especially of the Christian Chinese medical student. The reader will probably conclude after reading these letters that the medical missionary has really very little time to feel at all, so multifarious are his activities and so wide is his sphere of service. What he cannot fail to realize is that this work is indeed, as Dr. Robin says, " a worth while job ".

The familiar style, due to the epistolary form, is bright and racy, although there are a few expressions, such as " Med. Mish." (medical missionary) which must offend the ear of the reader with any pretension to literary taste.

On the whole, Dr. Robin provides food for some stimulating thought; his enthusiasm is refreshing and he has much to say which is well worth hearing; though we think, if he will allow us to say so, that a slightly more restrained treatment would have made his message more convincing and given to it a much wider appeal.

The Crippled Hand and Arm. By CARL BECK, M.D. Medium 8vo. Pp. 243 + xi, with 302 illustrations. 1925. London: J. B. Lippincott Co. 30s. net.

THIS work deals with deformities of disease, injuries, and congenital defects. The opening chapters on anatomy and physiology do not call for any special comment, except that we do not think there is an adequate description of the fascial spaces with which Kanavel's work has made us familiar. The section on congenital deformities has a large number and variety of conditions described, but we think that so well recognized a deformity as that of Madelung ought to have found a place, whereas this condition is only briefly mentioned; and that under the title of club-hand the deformity called the Strahlen defect should have been noticed.

The chapter on wounds and injuries is chiefly composed of an account of personally observed cases, and we note an ingenious method of substituting a toe nail for a lost finger nail. The remainder of the book deals with disorders of the wrist, elbow, and upper arm, but in most subjects the description of methods of treatment is not full or clear enough to be of much value. For example, the all-important subject of the technique of the transplantation of tendons and bone is dismissed in three pages at the end of the book.

The volume contains a great deal that is of value, but its incompleteness and inequalities tend to prevent its accomplishing the object with which it was written.

A Classification of the Tumours of the Glioma Group on a Histogenetic Basis, with a Correlated Study of Prognosis. By PERCIVAL BAILEY and HARVEY CUSHING. Medium 8vo. Pp. 175, with 108 illustrations. 1926. Philadelphia, London, and Montreal: J. B. Lippincott Company. 21s. net.

THIS monograph represents an attempt to correlate the structural differences of the cerebral gliomata with the well-known differences in clinical behaviour which exist amongst the tumours forming this, the largest, group of cerebral neoplasms.

Histological study of 400 gliomata by special staining methods has resulted in the differentiation of fourteen varieties according to the similarity of the predominant tumour cell to some stage in the differentiation of the cells arising from the neural groove. The relative degrees of malignancy, according to the average survival period from the date of the earliest known symptoms, are set out in a table. By this criterion the tumours range from the 'medullo-epithelioma', with an average survival period of ten months, to the 'astrocytoma fibrillare', with an average survival period of more than eighty-nine months. The most malignant tumours are those which reproduce the structure of the less differentiated cells in the developing central nervous system, whilst the more nearly they reproduce fully differentiated cell types, the more slowly do they grow and the less tendency do they exhibit to recur after removal.

The work constitutes an important addition to our scanty knowledge of the

nature and habits of the gliomata, and whilst naturally far from complete, it contains facts and suggestions which should be of great value to the surgeon who is called upon to deal with neoplasms of this kind, both as regards prognosis and as a guide to the extent of the operative measures to be pursued. The value of the book is increased by an excellent bibliography.

The Treatment of Fractures; With Notes upon a Few Common Dislocations. By CHARLES LOCKE SCUDDER, A.B., Ph.B., M.D., F.A.C.S., Consulting Surgeon to Massachusetts General Hospital. Tenth edition. Royal 8vo. Pp. 1240, with 2027 illustrations. London and Philadelphia: W. B. Saunders Co. 55s. net.

THIS has now undoubtedly become the standard book on the subject in the English language. It certainly has no rival in the matter of completeness. The present edition is a considerable enlargement of the work and presents several new features. Of these the most notable are articles by special authors—namely, on pathological fractures by Bloodgood, bone repair by Bancroft, the maxilla and mandible by Thoma, massage by Mennell, anæsthesia by Richardson, and birth fractures by Truesdell.

It is difficult in the space at our disposal to do justice to this book. It really forms a reliable encyclopædia on the subject and it includes practically everything of importance which one may need to know. The new sections, especially those on pathological fracture and on bone repair, are of great value. Fractures of each region are first described systematically and the general lines of treatment for each variety are laid down. Special operative methods and bone-grafting are separately and fully considered in later chapters. The only criticism that can be made about the book is based on its attempt at completeness tending to confusion. The reader has so many appliances and methods presented that he may become bewildered unless he has enough experience himself to apprize the value of each thing presented. Certainly no consulting surgeon or library can afford to be without this volume.

Principles of Surgery for Nurses. By M. S. WOOLF, M.A., B.Sc., M.R.C.S. (Eng.), L.R.C.P. (Lond.), Instructor in Surgery, University of California Hôspital, San Francisco. Demy 8vo. Pp. 350, with 89 illustrations. 1926. London and Philadelphia: W. B. Saunders Co. 15s. net.

EVERYONE who has had to teach surgery to nurses will appreciate the difficulty of presenting the subject clearly in the compass of a small book or a short series of lectures. In the present work of twenty-four chapters the author has tried to cover the ground in such a way as to give a clear account of all the common surgical conditions and their treatment. In this we think that he has been successful, but that he would have succeeded better if he had been content to dwell on important common and typical conditions, leaving out rare things altogether. Each chapter ends in a tabular summary which is much too complicated either for reference or memory. The figures are very good, but here again too many rare things and not enough common ones are illustrated—for example, the chapter on fractures gives only X-ray illustrations, and no kind of splint, bandage, or fracture bed is figured.

Modern Methods of Amputation. By THOMAS G. ORR, A.B., M.D., F.A.C.S., Professor of Surgery, University of Kansas. Royal 8vo. Pp. 117, with 125 illustrations. 1926. London: Henry Kimpton. 16s. net.

IN his preface the author rightly insists on function as being the final test to which all amputations must be subjected. The book is divided into six chapters. The first two are the best in the book. The former of these deals with "General Considerations" and the latter with "Amputation Stumps". These sections are ably written, concise, and cover the ground well. As was to be expected considering the position and reputation of the author, the opinions expressed and the advice given are thoroughly sound on most points. He favours the aperiosteal method of Bunge for

dealing with the cut end of the bone. We cannot quite agree with the wisdom of curetting out a small quantity of the medulla from the end of the bone. The development of spurs depends on the condition and behaviour of the periosteum and not on the medulla. The next two chapters dealing with individual amputations are not quite so good. Their chief fault lies in their being too short. The value of the book would be much enhanced if more minute directions were given for the performance of some of the operations, e.g., Syme's amputation. We are glad to see the author considers it unwise, as a rule, to leave a single toe on a foot when the remainder have been amputated. The fifth chapter is devoted to 'Cinematiplastic Amputations', but we are inclined to question the wisdom of including these. In this country at any rate this method has been given up entirely on account of the great difficulty of fitting efficient apparatus, a point which is not alluded to by the author. In the final chapter artificial limbs, both temporary and permanent, are described.

The volume is well illustrated with over a hundred drawings and photographs. We can thoroughly recommend the book to the student and surgeon, though no doubt the former would be glad to receive just a little more detailed information about some of the individual operations.

Appendicite. By F. CANEVA ZANINI. 8vo. Pp. 96. 1926: Milan Soc. Editrice Libraria.

THERE is something very pleasant about a little book, hardly more than a pamphlet, which includes abstracts of its contents in English, French, and German. A critic, conscious of his own deficiencies in writing Italian, must treat the English of his Italian colleague with great tenderness; it is so nearly good that it is a pity there was not an Englishman at hand to put a final polish on the prepositions, for example, and to prevent the inclusion of 'fracture of the pelvis' among the complications of operation for appendicitis; presumably ventral hernia was intended. The opinions of a surgeon with the immense experience of the Ospedale Maggiore behind him cannot fail to be of interest, but taken as a whole the views are those that were prevalent here fifteen or more years ago; it is the period of the cry, "send your cases early, we beseech you". Professor Zanini scouts any idea of blood-borne infection or association with 'influenza' and thinks fæcoliths and foreign bodies of little account: the infection is definitely enterogenous. He says that appendicitis is becoming continually more frequent in Milan, so that to-day the numbers admitted are as great as those recorded for accidents. He finds males more frequently attacked than females; the years 15 to 30 those most prone, and those classes more liable which have greater facilities for over-eating.

Occlusione intestinale. By O. MARGARUCCI and U. STOPPATO. Royal 8vo. Pp. 376. 1926. Rome: A. Manuzio.

THIS monograph, reprinted from the *Archives* of the Italian Surgical Society, embodies a report on the subject made to the Society by the authors, based in part upon materials, statistical and clinical, supplied by members, but contains also a conspectus of the literature of intestinal obstruction.

Professor Stoppato deals with etiology, morbid anatomy, and physiology; Professor Margarucci with symptomatology, diagnosis, and treatment. It is not an easy book to read, but since it is systematic it should be useful for reference despite the absence of an index. There is, in the nature of the case, little attempt to indicate the relative frequency and therefore importance of the various causes, and the statements as to the symptoms of some of the rare conditions must be founded, it would seem, on scanty information. At the same time, rarities of one clinic may be commonplaces of another, for among 468 cases of acute intestinal obstruction recorded by Bagozzi from the Ospedale Maggiore, no fewer than 168 were due to fæcal accumulation.